CO₂ EMISSION REDUCTION IN TRANSPORTATION SECTOR FOR SUSTAINABLE DEVELOPMENT: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

Development of economy activities and energy demand are increasing rapidly, influenced the high utilization of vehicles in the transportation sector. The paradigms led to an increment of CO₂ emissions and cause a wide range of environmental issues globally. CO₂ emission stands as the largest contributor to greenhouse gas emission with 65% of the total emission. Road transportation sector itself constitutes 85% of total CO₂ emissions in Malaysia. This paper reviews the issues and challenges facing in Malaysia for CO₂ reduction towards sustainable development in the transportation sector. Further emphasis is given to the current development of low carbon emission by promoting green transportation as a major factor to overcome the climate change issues. National Green Technology Policy (NGTP) that has been launched is also highlighted. Overall, this comprehensive review offers an extensive knowledge of recent greenhouse gases (GHG) emission scenario, opportunities for green transportation (GT) as well as an alternative energy implementation. This study also assists researcher and national policymakers for sustainability and environmental consideration in developing and promoting green transportation as the major solution for future energy demand and economic growth.

Keywords: CO₂ emissions, Greenhouse gases, Sustainable development, Energy policy

Introduction

Transportation plays an important role in socio-economic growth and mobility. The rising of energy demand and economy activities due to the development and human population has raised vehicle utilization in the transportation sector. In fact, this sector is necessary for global development, however, it is crucial to take into account for its substantial environmental impact. Fig. 1 shows in 2014, the transportation sector is the second largest contributor of global CO₂ emission. This sector accounted for 23% of global CO₂ emission and without a concerted effort to control the rising trend of fossil fuel usage, it is expected that in 2030, CO₂ emission will increase by 50% and more than 80% in 2050 (IEA, 2012). In Malaysia, transportation still relies on the traditional fossil fuel types includes gasoline and diesel. Each year, these activities produced millions of tons of greenhouse gases (GHG). Albeit, Malaysia shares only 0.7% of total CO₂ emission in 2015 (Olivier et al., 2012), the main concern lies on the escalating trend of fossil-fuel combustion CO₂ emissions. Hence, an effort towards a zero carbon economy is extremely desirable to preserve the environment.

In the effort to reduce CO₂ emissions, many countries including Malaysia actively involved in international consensus especially in United Nations Framework Convention on Climate Change (UNFCCC). In the Cancun agreements, a framework is provided for all major developed and developing countries to anchor their greenhouse gas targets in a parallel manner by 2020 (Mason, 2011), relatively Bali declaration emphasized the joint efforts by both developed and developing

countries in taking measures of climate change (Allan et al., 2007). Under Tenth Malaysia Plan (2011-2015), the government formulated its New Energy Policy with focus on improving the environmental quality by undertaking climate change mitigation, protecting from its impact and enhancing conservation of the nation's ecological assets.

Definition, evaluation and implementation of sustainable development in transportation have been review by several authors (Gudmundsson and Höjer, 1996; Jeon and Amekudzi, 2005; Litman and Burwell, 2006). In 10th Malaysia Plan, green growth is a development path that considered three pillars of sustainable development encompasses economic, social, and environment. In fact, sustainable development has become a main global concern. Sustainable development is defined as the development that meets the current needs without compromising the ability of future generations to meet their own needs (Morelli, 2013). In the Anthropocene, sustainable development is viewed as development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of current and future generations depends (Griggs et al., 2013). Plan and decision by the authority and government formulate today will have a long-lasting impacts on socio-economic development and climate since transport infrastructure lasts for decades. Thus, transportation plays a vital role in achieving the sustainable development globally as most of the main factors for growth and modern economic rely on this sector.

This paper is organized into sections. Section 2 represents the role of transportation in global and Malaysia scenarios. The current development of green transportation for sustainable development and the government's NGTP are outlined in Section 3. Section 4 discusses the opportunities and challenges involved in promoting and implementing clean energy vehicles towards green in Malaysia. Lastly, Section 5 presents the conclusion of this paper.

Fig. 1: World CO₂ emissions from fuel combustion by sector in 2015 (International Energy Agency (IEA), 2017).

Role of Transportation and Green Focus

Transportation holds a crucial part in the effort to mitigate the impact of climate change. Preserve the environment without neglecting the gas emission produce from the transportation is important as well as the important to the socio-economic development. In 1992, the role of transportation in sustainable development was first documented at the United Nation's Earth Summit and reinforced in its outcome document; the Agenda 21. The first ever Global Sustainable Transport Conference in 2016 has identified the basic role of sustainable transport in fighting climate change and achieving sustainable development. The focus of the conference is to promote sustainable transport and the establishment of affordable, economically viable, socially acceptable and environmentally sound transport systems which are crucial for the achievement of the 2030 Agenda for sustainable development.

Fig. 2 represents carbon emission in metric tons per capita including Malaysia and other developing countries in Asia such as China, India, Indonesia and Singapore. The graph shows an increasing carbon emission except for Singapore, while Malaysia's carbon emission of 7.7 metric tons per capita, which is approximately 40% more than the world average emission.

Fig. 2: Carbon Emissions in ASEAN countries (World Bank, 2015).

The road transport vehicle in Malaysia has increased drastically from about 5 million in 1990 to 23.7 million in 2013 with the annual growth rate of 7.4% (MOT, 2013; Mustapa, 2016). It is clear that the transportation and economic factors correlate with each other which transportation sector is a vital component of the economy impacting on the development and the growth of population.

On the other side, transportation activities have resulted in growing levels of most pollutants and therefore have an effect on the environment. Based on data of transportation emissions, road transportation accounts 85%, of CO₂ emissions, with about 59% of overall comes from cars (ASEAN - German Technical Cooperation, 2016). Addressing the critical issues on the climate change, promoting and implementing the strategy for green transportation is considered most important without impeding the socio-economy growth. Bjorklund (2011) defines green transportation as: "Transportation service that has a lesser or reduced negative impact on human health and the natural environment when compared with competing transportation services that serve the same purpose". Obviously, green transportation is the solution to reduce the emission of harmful gases that could impact the environment and human health. It is referring to the convenient, safe, zero and low emission, efficient and effective resources and smart transportation system.

In return, green transportation provides a healthy and leisure lifestyle and the construction of green transportation system is beneficial for the intensive road resources consumption to ease the traffic congestion, reduction of energy consumption for energy conservation, improvement of air quality and greenhouse effect via reduction of gas emission as well as a livable cities for improvement of human health (Li, 2016).

National Green Technology Policy (NGTP)

Research of conversion and utilization of CO₂ via advanced technology to mitigate the anthropogenic CO₂ emission have been carried out and the direction is presented as well. One of the directions includes the converting CO₂ for fuel synthesis via renewable energy sources for sustainable development (Wu and Zhou, 2016). Efforts on the GHG reduction have increased a stakeholder's major concern on the development of transportation sector which will affect the national economic growth and community livings. Thus, policy and strategies need to be addressed towards

environment-friendly of transportation to achieve Malaysia aspirations for sustainability. In the year 2009, National Policy on Climate Change (NPCC) and National Green Technology Policy (NGTP) have been endorsed by Malaysia's government based on the fundamental strategy to ensure climate resilient development in fulfilling national aspirations for sustainability.

In 11th Plan, Malaysia has set principal outcomes of reducing GHG emission intensity of Gross Domestic Product (GDP) by up to 40% compared to 2005 levels by the year 2020 (Eleventh Malaysia Plan, 2016). The framework of green growth strategy has been introduced which covers four focus areas. Basically, the focus of four areas continues in mapping a shift-modeled toward green growth that includes strengthening the enabling environment for green growth, adopting the sustainable consumption and production concept, conserving natural resources for present and future generations, strengthening resilience against climate change and natural disasters. This framework extensively will lead to the vital transformation of sustainable and resilient development.

The launch of the NGTP in 2009 reaffirmed the government's objective to accelerate the development of renewable energy or green technology which address on long-term sustainability, reliability and security of energy supply for continuous development growth (MEGTW, 2009). NGTP is developed on four pillars: (1) seek to attain energy independence and promote efficient utilization; (2) conserve and minimize the impact on the environment; (3) enhance the national economic development through the use of technology; and (4) improve the quality of life for all whereas five strategic thrusts involved: (1) strengthen the institutional frameworks, (2) provide conducive environment for green technology development, (3) intensify human capital development in green technology, (4) establish green technology research and innovations, and (5) promotion and public awareness. Thus, to develop green transportation, the focused sector should involve the strengthening of policy and regulatory, green technology advancement, human capital development and financial instruments. Essentially, four key areas are adopted for major improvement and significant progress for the better quality living and a healthy environment. This includes energy, water and waste management, buildings and transportation sector. Integration of Green Technology in the transportation infrastructure and vehicles is important to ensure the national goal of the Green Technology Policy is fulfilled.

CO₂ emission reduction in the transport sector that focus on exploring effective policy options presented in various studies by researcher and industrial practitioner. Hickman et al. suggested low carbon vehicle technologies supported with the effective set of policy would be an important strategy for CO₂ emission reduction. Apart from that, Ong et al. proposed that promotion of natural gas vehicles and fleet renewal will influence carbon emission reduction in Malaysia. In this regard, a prompt action via selection of major plan needs to initiate for a drastic result of CO₂ emission reduction which includes an implementation of alternative green technology and an efficient public transportation in urban areas. Many projects involved especially for public transportation such as Mass Rapid Transit (MRT), Light Rail Transit (LRT), train and busses have been planned and implemented. CO₂ emission reduction also involved an initiative to improve vehicle standards, energy efficient vehicles, diversification of fuels and strict emission testing system that has been introduced by Ministry of Transport Malaysia and Department of Environment Malaysia for vehicles (Shahid et al., 2014). Therefore, in Malaysia context, more analyses and formulations of policy strategy plans are needed to determine the most applicable and effective assessment to be implemented in meeting the target for CO₂ emission reduction.

Challenges and Opportunities in Road Transportation for GHG Reduction

Transportation sector in Malaysia uses approximately 46.6% of total energy demand and generates nearly to 50 Mt of CO₂ to the atmosphere each year (Energy Hand Book Malaysia, 2015). After electricity power generation sector, transportation stands as a second contributor of CO₂ emission which road transportation is the largest share followed by aviation, maritime and rail. The threat from GHG emission bring severe impact to human, one of the world's major studies represents the long-term exposure to air pollution and traffic noise can effect on blood pressure (Financial Times , 2016). Realizing reductions in global GHG emissions is not that easy, there are several economic, social and political challenges to solve at first. These involve difficulties of public education awareness, lack of human resources and workforce skill, high cost and reliability involve in implementing green energy technologies, energy policy, conflict of vested interests and coordinating a global consensus among countries at different economic level.

Constructing a policy which regards to GHG reduction is essential in every country. As aforementioned, Malaysia has introduced National Green Technology Policy (NGTP) to boost the development in the transportation sector for sustainability. It has been viewed as long-term strategies of GHG emission reduction; however, the challenging is to design multidimensional aspects of the strategic plan that should align with enforcement and ability to adapt to the focused-sector.

More population worldwide lived in urban than in rural area. Rapid urbanization delivers massive job opportunities that lead to a high demand for an efficient transportation system. Public transport and infrastructure improvement are essential to minimize the impact of pollution. This situation asserts the need for green transportation for a healthier environment and sustainable development. Investment for transportation's efficient system consumes high in cost, for example, the first phase of Malaysia's MRT system which cost US\$5 billion. These major projects involve three phases and one of the projects in Malaysia Economic Transformation Programme (ETP) to develop nation and high-income country. Other future largest transportation project ever in Malaysia is High Speed Rail (HSR) which linked between Kuala Lumpur and Singapore cost around US\$10 billion according to industry experts. Also, East Coast Rail Link (ECRL) project that covers 600 km of electrified double-tracking lines and urban transport MRT3 worth about US\$13 billion and US\$12 billion respectively. All these largest infrastructure projects in transportation sector are targeted to stimulate economic growth and jobs opportunity to locals, however, according to industry players, the project involved is one of most expensive railway to be built in the world (Jose, 2016). The element in terms of economic feasibility is still questioned with depreciation of the Malaysia currency and economic slowdown.

In aggregate, investments by countries and industries in energy research and development are modest compared to other sectors. The progress of implementing alternative clean energy technologies into the public mainstream is quite slow and financing is still the main issue to be solved. These technologies use in the vehicles such as battery, hydrogen fuel cell (HFC), biofuel and compressed air (CA) are unlikely to attract more public consumer unless the constraint of limited distance can be solved. Indeed, industrial player, especially in the automotive sector, has put a lot of effort to solve this issue in penetrating these alternative clean technologies into market. Addressing the issues of reliability and high cost, these technologies have created to public depreciation level of confidence and yet it's still unfavorable choices of transportation. Apart from that, distribution infrastructure should be set up in providing a high demand for alternative energy resource. Improving public recharging network is important to supply demand for vehicle using alternative energy. The readiness of charging infrastructure, for example, will encourage customer to consume electric vehicles (EVs), fuel cell vehicles (FCVs) and others alternative clean energy for better security of energy supply.

Implementation of alternative clean technologies for CO₂ reduction will develop a necessity for expertise and high-skilled workforce. Thus, initiatives should be taken from higher learning institutions to help students develop their knowledge and skills in this sector. Various courses should be reviewed accordingly to the needs of the technology and it is a vital role for the ministry of higher education as well as academicians to address this challenging issue of sustainability. The concept of green transportation should be exposed intensively to the government official involved to prevent low awareness in meeting national policy and plan towards sustainable development. Albeit, energy consumption and CO₂ emissions are acknowledged as vital issues, most of the primary objective of the policy is referred in achieving economic goals and growth whereas environmental awareness stands as a secondary. This unbalanced circumstance will sacrifice a long-term impact on the sustainability of transportation sector for only to meet the shorter period of economic goals.

In the effort to reduce CO₂ emission, public transportation has to be developed and concurrently there is a need for transport hub interconnectivity. Insufficient of hub connectivity will reflect the total number of the public user of the service. An improper link between public transportation centers indeed will lead to substantial inefficiencies of the transportation system. By contrast, transport center interconnectivity should be well planned and easy access link so that public preferably uses the service.

Lack of public awareness relating to green transportation will deny the objective to reduce CO₂ emission. For example, as many public using their own vehicle to move, a high amount of vehicles will be on the road that will cause congestion. The vehicle emits higher emission and creates inefficiency of energy consumption as well as potentially will risk the environment. Therefore, public education should be implemented at the appropriate level with the attention to increase public awareness on the global issues.

Holistic management systems for sustainability is a necessity in prompt due to growing global concern towards sustainable development that emphasizes the development in economic, environment,

and social aspect (Li et al., 2015; Lee et al., 2017). A wide range of opportunities is available from GT implementation in the energy imminent transition to alternative clean energy vehicles towards sustainable development. GT via public transportation bring a vast opportunity either directly or indirectly. More jobs are expected to be created and possibly encourage income growth as well as the increase in GDP. Indeed, modern, efficient and safe mode of public transportation will increase the productivity level of society due to less time wasted in heavy traffic jams. With the rise of living cost and household debt, the presence of green public transportation will be able to diminish the negative impact and improve society overall wellbeing. As many people utilize the public transportation, a low occurrence of accidents is expected on the road. Consequently, nearly US\$2.25 billion of loss to the economy as well as the society can be saved due to this negative impact.

Planning and existing of reliable public transportation projects provide easy access to people from one place nearest to farthest area and created trade market between cities connected. For example, future ECRL project enables connectivity of ports and townships such as Port Klang, ITT (Integrated Transport Terminal) Gombak, Bentong, Mentakab, Kuantan, Kemaman, Kerteh, Kuala Terengganu and Kota Bharu whereas High Speed Rail (HSR) project connects two big cities of Kuala Lumpur and Singapore. Efficient and fast transportation provide various benefits in terms of meeting customer demands and needs.

Decarbonizing energy sources is one of the efforts which are essential to mitigate the risks of climate change. Diversity of clean energy sources reduce oil dependency and contribute to sustainable development for country growth. The application of clean energy sources such as electric, hydrogen fuel, biofuel and compressed air offer a clean environment and opportunity in terms of new discovery which lead to various research and development. Aggressive exploration in focused research especially in alternative energy and transportation will create a new business, market opportunity and boost nation's economy. Many largest automotive companies have launched their multiple EV models that lead to potential EV business and global market prospect. Nissan, a Japanese automobile manufacturer has started production of the all-new EV, at its Sunderland plant, which will manufacturer Nissan LEAF the company's best-selling EVs to European customers and lithium-ion battery production at an initial investment of £420 million. In Sunderland plant, more than 2,250 jobs are created under Nissan as well as in the UK supply chain (Herron and Wardle, 2015). Additionally, along with the rapid technological progress of EVs, others opportunity in battery and cell manufacturing subsequently will emerge and grow as well. In fact, government policy to restrict the use of conventional combustion engines to cut down on vehicle emissions will see a petroleum company investing in this alternative energy as a new business potential.

Wide job opportunity is anticipated to increase with many industries interested to explore and invest in the clean energy sector. One of the largest oil companies in the world, Exxon Mobil is making a huge investment in the forms of alternative energy as the company commitment not to rely on fossil fuels. The company is investing \$1 billion per year in research and more than one hundred projects under the company's will receive funding, involve of producing biofuel from algae and reaction of carbon dioxide rather than natural gas or hydrogen to produce fuel cells. This is an opportunity for various small companies and universities to participate and collaborate on a huge array of projects in shifting reliance on fossil fuels to alternative energy sources. These efforts will benefit entire communities and even nation by ensuring sustainability of clean energy for the future.

Other aspects involve a synergy between researcher and automotive industry which enables more research and development towards breakthrough technologies. Thus, specialist and high-skilled workforce in the energy and transportation sector are high in demand. With that, promotion of GT in a large scope via deploying sustainable energy technologies surely will yield multiple advantages in terms of more clean, efficient, smart and autonomous vehicles. Further innovations are expected in mobility with emerging of various alternative energy, carbon capture and efficient of energy storage.

Conclusions

This research study has given a comprehensive review of the literature concerning the challenges and opportunities facing in implementing green transportation to reduce CO₂ emission for sustainable development. While energy consumption enables socio-economic growth, it also contributes two-thirds of global greenhouse gas emissions with transportation sector holds the largest share, therefore, it is critical for tackling climate change. Various policy makers, stakeholders, technology providers, industrial players, international organizations and academic institutions and experts should be participated extensively to avert dependency of non-renewable energy and finding solution for creating

economic growth while reducing the huge impact of GHG emission. In order to reduce major CO₂ emission, the policies and interventions should address the strategy of encouraging the adoption of alternative clean energy. National Policy on Climate Change (NPCC) and National Green Technology Policy (NGTP) implementation should enhance a green technology development while creating a zero emission and resource efficient economy. Improve policies enable an immense progress of Green Technology Roadmap towards the national economy and promote sustainable development. Though green transportation involves several challenging issues, there are more opportunity gains and positive impact in return. Clearly, green transportation is one of the main solutions to overcome the threat from GHG emission that can lead to the severe impact on ecological and economic disruptions. Green transportation will enable an increased probability of success and deployment of commitment to reduce CO₂ emission and thus, bring to healthy human population towards global sustainable development.

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