SECTORAL ENERGY-CO2 EMISSIONS USING AN ENVIRONMENTAL INPUT-OUTPUT FRAMEWORK

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ABSTRACT

Global climate change is an alarming problem nowadays. Weather temperatures have been uncertain because of what many scientists claim is the effect of greenhouse gases, contributed mainly by the energy industry. In Malaysia, the energy industry provides a significant contribution to it economy making up about 20 percent of the GDP. Malaysia is the third largest natural gas exporter in the Asia-Pacific region in 2011 and eleventh in the world (British Petroleum Statistical Review of World Energy, 2014). Malaysia's CO_2 emission recorded at 185 million tonnes in 2010 (International Energy Agency, 2012). Mohd Safaai et al. (2011) projected that without any mitigation measures 285.73 million tonnes of CO_2 will be released in 2020. In the Copenhagen forum 2009, Malaysia has pledged to reduce 40% of carbon emissions by 2020 compared to the 2005 levels. Motivated by the government efforts, this study will construct environmentally extended input-output framework for Malaysia to obtain the energy-related CO_2 emission intensities by sectors. The study is responded to the inadequate of reliable data on Malaysia's sectoral CO_2 emissions and to the growing awareness of the effectiveness of Malaysia climate change policies. This study expanding the current understanding of interactions among economic activities, energy intensities, and CO_2 emissions. Results of this study found that Transportation recorded the second highest contributor to CO2 emission, and these findings were different to many other existing studies that found transportation sector as a main contributor to CO_2 emission. In addition, results suggest that it is necessary to control environmental problems and encourage the energy use efficiency in the production process, particularly in the Building and construction sector, Transportation, Electricity, gas and water and Agriculture sector in Malaysia The findings will help the policy-makers particularly in Malaysia to develop a strategic plan and tools to manage CO2 emission with respect to climate change in these four sectors.

*Keywords:* Energy, Energy Intensities, CO_2 Emission, Climate Change, Input-Output Analysis.

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1. INTRODUCTION

Malaysia has relatively very high CO_2 emission as compared to other Southeast Asia nations, measures at 8.03 metric tonnes CO_2 per capita and 0.31 tonnes per GDP compared to Philippine at 1.06 metric tonnes CO_2 per capita and 0.15 tonnes per GDP, and Indonesia 1.81 metric tonnes CO_2 per capita and 0.17 tonnes per GDP (World Bank, 2014). Malaysia registered a continuously significant growing CO_2 emission throughout the period 1978-2016 as shown in Figure 1. Energy demand [1] also shown a similar trend which reflects the burning of fossil fuels like coal, oil and natural gas and the use of gasoline such as Ron 95, Ron 97 and diesel contributed much to the CO_2 emission. Despite the continue increased in CO_2 emission and energy demand, Gross Domestic Product (GDP) is fluctuating through-out the period 1978 to 2016 as pictured in Figure 2. During the high economic growth period, the CO_2 emission and energy demand grew significantly, while, during the economic recession, CO_2 emission and energy demand fell, but only marginally (Malaysian Energy Information Hub, 2017; World Bank, 2018).

Figure 1: Energy demand and CO_2 emission in Malaysia
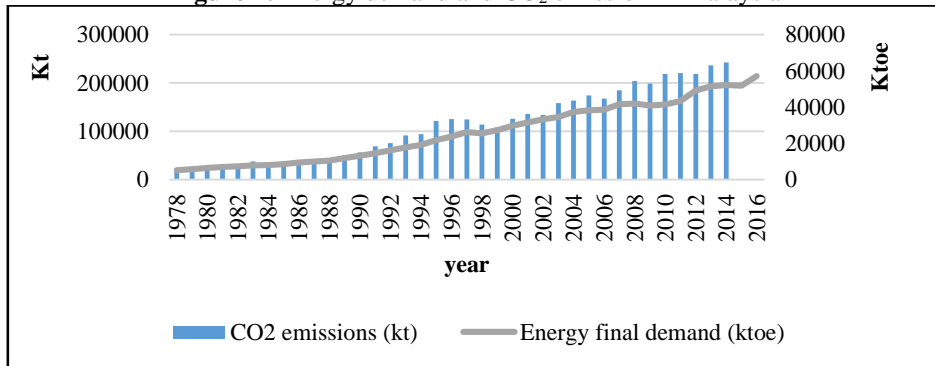
Source. Malaysia Energy Commission, 2017

Figure 2: Energy final demand and economic growth in Malaysia
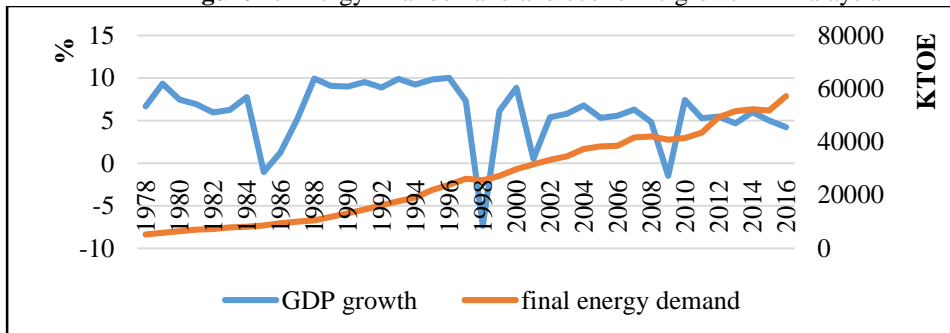

Source: Department of Statistics, Malaysia Energy Information Hub, Malaysia Energy Commission 2017, World Bank, 2018

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[1] Demand of coal, oil and natural gas, gasoline, diesel etc.

Figure 3 shows final energy demand by sector in 2016. The highest growth in energy demand is transportation sector with 42%, followed by industrial sector (28%), non-energy (15%), residential and commercial (14%), and agricultural sector (1%). It corresponds with result from Ong et al. (2012) who suggested that transportation sector keep increasing due to the growth in household income and number of vehicles on road.

Figure 3: Final energy demand by sector in 2016 in Malaysia
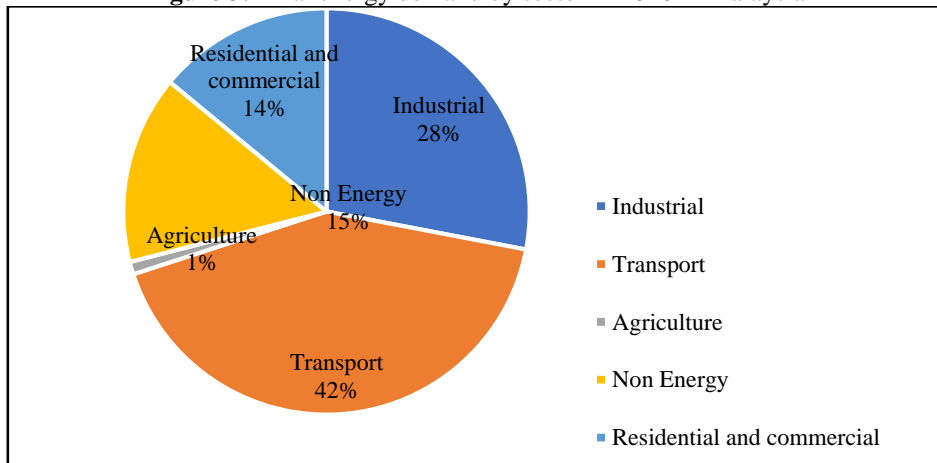
Source: Malaysia Energy Statistic, Malaysia Energy Commission, 2017

In light of significant increase in CO_2 emission and the global climate change issues, Malaysia is attempting to reduce the amount of CO_2 emission generated from its economic activities. The Prime Minister announced during COP15 in Copenhagen that the country would voluntarily reduce its carbon emissions intensity of GDP by the year 2020 by 40% compared to 2005 levels. Therefore, there is an urgent need for actions on CO_2 emission in order to avert its worst impacts on climate change. Directed by this we interested to find an answer to the following questions: (1) how big CO_2 emissions is produced by each sector? and (2) which sectors produce relatively higher CO_2 emissions? Accordingly, the objective of this study is 1) To estimate the CO_2 emission intensities of each sector, and (2) to identify sectors with relatively high CO_2 emission intensity.

This study is employing an environment energy input-output framework which it can be used in environmental studies by linking economic and environmental variables, on the production and consumption interventions. Environmentally-extended input-output (EEIO) evaluates the linkages between economic consumption and allows the estimation of energy emission intensities of each sectors and can maps all the interactions between the sectors in the Malaysian economy. The framework reveals the channels through which the environmental burdens of production activities are transmitted throughout the economy.

This study contains five sections, and the first section focuses on the background and objective of the study. The second section reviews the literature. The third section explains the methodology and model of the study. Section four covers the analysis of the results and discussions of the study. The final section highlights the conclusion.

2. LITERATURE REVIEW

There are several studies that have been investigated about energy consumption and CO_2 emissions which using several approaches in developed and developing countries. Yildizhan (2018) investigated the energy consumption and CO_2 emission in crop production and agriculture especially in strawberry production in Iran. He finds that total cumulative electric energy consumption for a ton of strawberry production is up to 6703.042 MJ in open field and 4200.881 MJ in the greenhouse. With regards to CO_2 emissions, to produce one ton of strawberry lead to production of 506.07 kg of CO_2 (greenhouse) and 243.06 kg of CO_2 (open field). Thus, higher energy consumption could lead to higher cumulative CO_2 in greenhouse compared to open fields.

Li, Ma, Zhang and Wen (2018) examined the energy demand and CO_2 emissions related to industries in China. Based on demand and supply theory, they indicated five sectors in demanding energy and CO_2 emission. The sectors are agriculture, industry and construction, transportation, service and residential living sectors. Agriculture demand consumption for coal as much as 55% of total final energy, transportation demand consumption for fossil-based fuels such as gasoline, diesel and kerosene as high as 87% of total final energy and industry and construction sector demand consumption for coal, oil, natural gas and electricity and heat as 88%, 36%, 55% and 71% of total final energy respectively. They concluded that final energy demand in China will increase tremendously until the year 2030 in all sectors afore mentioned above. With regard to CO_2 emission, they report that China should reduce CO_2 emission in the future between 80% and 85% using primary sources such as coal for all sectors. They suggested that the development of carbon capture and storage (CCS) technology or other carbon-negative technologies are important to implement in China.

Jia et al. (2018) analysed CO_2 emission by industries in Nanchang, China. By using index decomposition analysis, energy consumption in industries increased by 0.14 Mt with growth rate of 1.72% in the first stages of period 1998-2000, and then steadily increased by 7.42 Mt at a rate of 89.34% in the second stage of period 2001-2005. In the third stage of period 2006-2010, this energy consumption increased again by 5.71 Mt at a rate of 36.28% and grew by 3.35 Mt at a rate of 15.60% in (2011-2015), with a total growth rate of 203.42%. However, the CO_2 emission is dropped to -9.42% during the periods of 2006-2010 due to global economic crisis commenced in 2008.

Leesombatpiboon and Joutz (2010) investigated seven major economic sectors of Thailand economic including agriculture, construction, electricity, manufacturing, mining, residential and commercial, and transportation. They found that transportation used largest share as 38% of the total energy consumption. Meanwhile the second and the third major energy users are the industrial and residential and commercial sectors as about 32% and 24% of the total energy consumption respectively. Regarding to the petroleum products, transportation and agriculture are major consumption of high-speed diesel (HSD), while manufacturing and electricity sectors take the largest share equally 43% of total fuel oil consumption.

Wu et al. (2018) employed data development analysis to look at energy use, CO_2 emission and economic-environmental efficiency performances in Asia-Pacific Economic Cooperation (APEC) for the period of 2006-2010. They found that Russia, Malaysia and Indonesia performance were worse compared to other countries. In terms of sectoral emitted to emission, they found that most

of the CO_2 emission in Russia, Malaysia and Indonesia derived by manufacturing industry of 37%, 44% and 47% respectively.

Similar findings also find by Supasa et al. (2017). They studied using the consumption-based approach finds that the manufacturing, commercial, construction and road transport sectors were leading of CO_2 emitters in Thailand. On the other hand, using production-based approach, they find that petroleum sources and power generation sectors are responsible for the nation emission. In addition, based on consumption with international trade and embodied emissions from imports and excluding those from exports, Thailand exhibit lower in CO_2 emission for the years 2000 and 2010.

Particularly in Malaysia, Ong et al. (2012) claimed that transportations are the main contribution to CO2 emission because transportations are highly depending on petroleum products such as gasoline and diesels. Studied by Mustapa and Bekhet (2016) show out of the total CO2 emissions in transportation sector, road transportation account for the largest share with 85.2%, followed by aviation, maritime and rail. Begum et al. (2015) indicated a huge proportion of CO_2 emission comes from energy consumption of the power, industrial and transport sector. Similar findings also reported by Othman and Jafari (2013) where they show the primary key sectors that demonstrate the strong distributive and total effects were dominated by the energy industry and transportation sectors and were identified by calculating the emission elasticities that describe the relationship between CO_2 emissions and the income generated in the country. In terms of economic expansion in relation to CO2 emission, Mustapa and Bekhet (2016) found that the CO_2 emission in Malaysia increase in line with GDP growth. Shahbaz et al. (2013) also found similar result where economic growth has significant positive relationship with CO_2 emission. A 1% rise in economic growth cause 0.7219% rise in CO_2 emission.

3.   METHODOLOGY

The Environmentally input output framework is employed in this study. This framework shows a complete picture of the economic system. It traces intersectoral relationship direct and indirect inputs used in the production process and can be used in environmental studies by linking economic and environmental variables on the production and consumption interventions (Hassan et al., 2014).

The Environmentally input output framework is suited to model the interlinkages between a range for environmental indicators and detailed structural economic information at the sector level for the analysis of energy policies. The proposed framework can be utilized as a tool for energy and environmental policy decisions which consider the impacts to resource consumption and environmental emissions.

We constructed an Environmentally Input-Output Table of Malaysia following the structure provided by Eora information by the (World Input-output Database, 2015). The individual country tables are available for download, and contain primary input, final demand blocks, imports and exports itemized by partner, and environmental satellite accounts for individual countries. Data are provided both Producers Prices (basic price) or Purchasers Price, and are in tab-delimited text files, which can be opened in Excel or any programming language.

We decided to use all CO_2 emissions from many types of energy use from all the sectors. In this model the country has been aggregated from 96 sector to a common 27 sector classification. The environmentally input-output table of Malaysia is following the structure provided by Eora IO table information, provided CO_2 emissions from all the 27 sectors. The table is divided into the transaction's matrix T, primary inputs (also called value added), final demand, and satellite accounts Q for emissions associated with production and final consumers. The model for Malaysia is derived from the structure of the energy intensity of Malaysia environmentally input-output table.

Table 1: The structure of Malaysian environmentally input output table

Sector	Sect 1	Sect2	Sect 3	.	.	Sect 27	Final Demand	Gross Output
Sect 1								
Sect 2							Final	
Sect 3			Domestic transactions				demand	
.								
.								
Sect 27								
Primary Inputs			Value added					
Total Input								
Satellite Account (Q)			Satellite Account (Q)					
Direct Emission (Kt CO₂)								

A Leontief price model has been implemented to investigate the potential impact of a CO_2 taxation in the Malaysian economy (Harun et al., 2018). Based on Gemechu et al. (2014), the emission intensity Q:

$$Q = e'(I - A)^{-1} \tag{1}$$

where vector Q in equation 1 is the CO_2 intensity of each sector, e' is a row vector of sectoral emission in which each element e_i represent the amount of CO_2 emission produce a unit output of sector j, A is n-by-n matrix of technical coefficients, whose element a_{ij} measures the flow from sector i required to produce a unit output of industry j (Ying & Harun, 2019).

4. RESULTS

The Carbon dioxide emission shows a large difference within 27 economic sectors in Malaysia as pictured in Figure 4. The high emissions were the result of Public administration with 89 million per metric ton carbon dioxide. This is associated with the huge use of energy by the Public administration. The other findings, for example in UK also shows the influenced of the amount of CO_2 emission by public sector, and they are reducing their carbon emission by more than 17.5 million tonnes in the public sector since 2003 (Carbon Trust Organisation, 2017). Transportation

is the second largest contributor to Carbon dioxide emission with 79 million per metric ton, results of burning fuel for cars, trains, and planes. Third highest emission sector was Electricity, gas and water which contributed 51 million per metric ton carbon dioxide. Meanwhile, the lowest emission sectors are represented in many services sectors such as Health and education, Real estate, Insurance, Hotel and restaurants and Wholesale and real estate.

Figure 4: Carbon Emission by Sectors
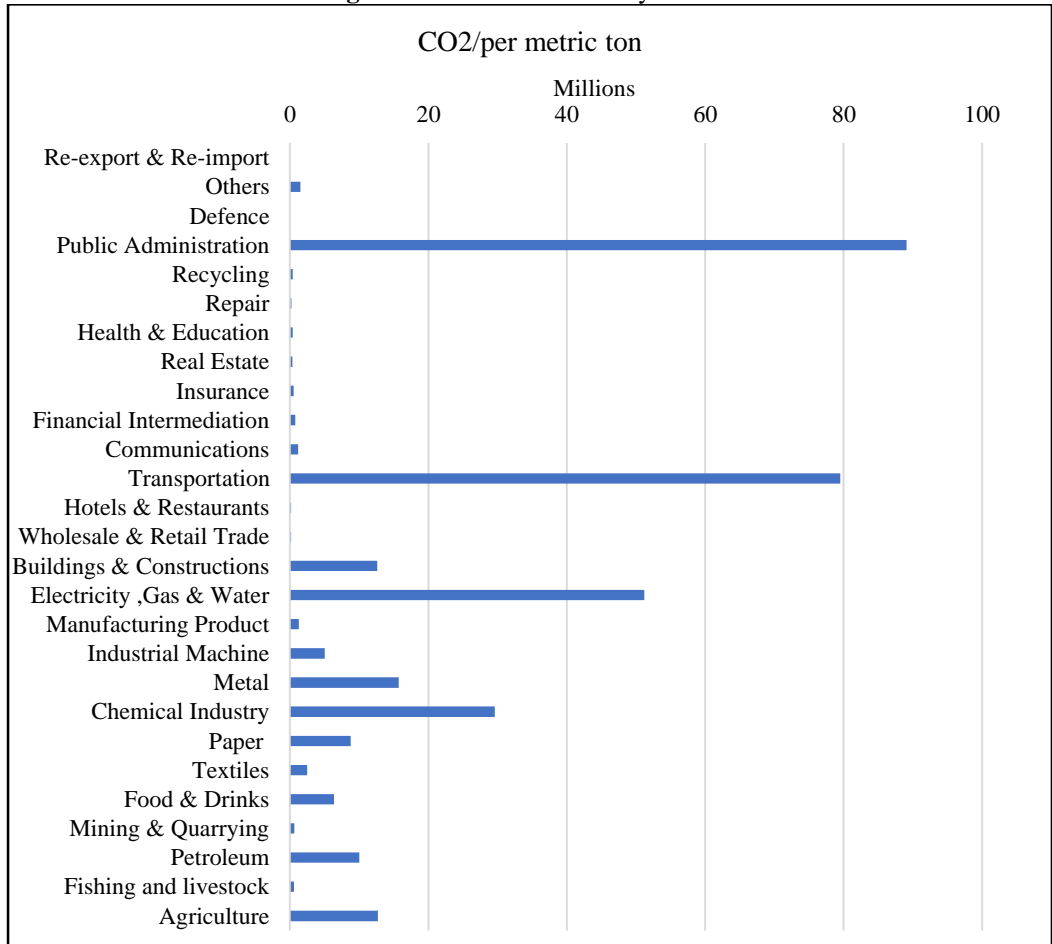
In term of CO2 energy intensities, there are also signficant differences in the CO_2 emissions intensities within the 27 economic sectors as shown in Figure 5. According to a traditional definition, CO_2 intensity measures the amount of CO_2 emitted per unit of output (ton of CO_2 per output-\$). However, this study that based on Gemechu et al. (2014) has broader definition of CO_2 intensity, incorporating direct and indirect CO_2 intensities. The amount of carbon emission produce by one sector is related to its productivity and technology efficiency. If a sector's carbon emission per ton is low comparing to its output, the CO_2 emission intensity will be low representing high

technology efficiency. Based on the Gemechu et al. (2014) calculation, the high emission intensity is levied on Building and construction sector, reflecting high consumption of energy in the production process for example cement, ceramic product in construction process. It could reflect the speed increase of the development level of economic expansion that forced the acceleration of the growth of the carbon emissions.

Next to Building and construction sector, Transportation, Electricity, gas and water, Chemical industry and Agriculture marks. Transportation high carbon emission intensity highlights the significant growth in the transportation development of railway, highway, water transport, and aviation, while high carbon emission intensity of Electricity, gas and water indicates its vital role in economic development. The Agriculture sector include production of oil palm, tea and rubber primary product which comprising a high energy demanding process, thus led to the high carbon emission intensities. In contrast, Insurance, Repair, Hotels and restaurants, Wholesale and retail trade, financial intermediation and Fishing and livestock have a low emission intensities level with respect to energy utilization.

Figure 5. The emission intensity by sector
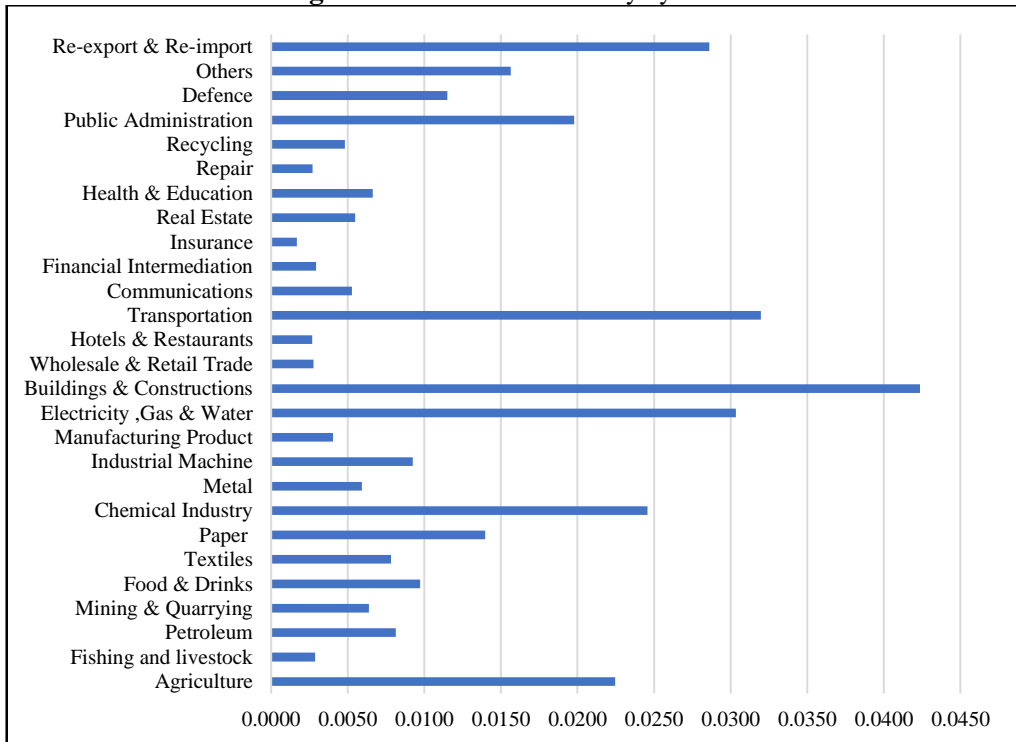
Sources: own calculation based on World input-output Database, World data Atlas Malaysia Environment.

5. CONCLUSION

These results suggest that it is necessary to control environmental problems and encourage the energy use efficiency in the production process, particularly in the Building and construction sector, Transportation, Electricity, gas and water and Agriculture sector in Malaysia. Government should have a strategic plan and tools to manage CO_2 emission with respect to climate change in these four sectors. It is also critical to identify the contributing factors of these sector carbon emissions intensities. In contrast to many other existing studies that found transportation sector as a main contributor to CO_2 emission, we got different result where Transportation recorded the second highest contributor to CO2 emission.

Malaysia, as other developing country, must reduce carbon emissions because the country is one of the top Co_2 emitting countries in the ASEAN region and depend heavily on fossil fuel in the development and promoting its economy. These findings suggest that it is necessary to control environmental problems, improving carbon emission efficiency and reducing carbon emissions in Malaysia. It is also critical to identify the contributing factors of these sector carbon emissions intensity. Thus, the major policy proposals these results suggest that policy makers should coordinate and promote the economic development and environmental resources.

The study recommends implementing a carbon tax that can be used to fund investment in alternatives energy, lead to further technological developments which has lower pollution costs. This environmental tax has been created in the developed world, particularly in the European Union (EU) since the ninety's century.The direct and indirect effects of co_2 taxation in Malaysian could either be through a direct reduction in emissions that could be attained from the change in output induced by the tax, or through the use of parts of the revenues to stimulate cleaner technology.

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