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Review Article

CARBON CONSERVATION IN MALAYSIA'S INDUSTRIAL SECTOR: A REVIEW

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Abstract

The increasing rate of human-caused greenhouse gas (GHG) emission levels has ledto a significant rise in global temperature. A large number of GHGs are released during the combustion of fossil fuels in end-use sectors. GHG emissions cause global warming and climate change, with CO2 recording for nearly 72% of total GHG emissions. When statistics show that Emissions of carbon dioxide have increased 1.6 times in thelast three decades, the importance of researching GHG decreases in different nations becomes even clearer. Even though Malaysia is notspecified in Annex 1 of the Kyoto Protocol (KP), this developing country has actively participated in GHG reduction projects under the KP.GHG emissions are increasing in Malaysia as a result of visible growth in industry and a growing population. The Malaysian government has prioritized fuel usage efficiency, optional fuel utilization, and palm tree plantation as key objectives. This review provides an outline of Malaysia's key sources of GHGs and examines the preventive measures that the Malaysian government should adopt to reduce CO2emissions.

Keywords: Greenhouse Gases, non-renewable energy, Malaysia, $C0_2$.

INTRODUCTION

Since Malaysia gained independence, the financial system has expanded quickly, which can be attributed to the 1985 Industrialization Plan's effectiveness in hastening the structural transition away from an agricultural-based economy. During the Asian Financial Crisis of 1997–1998, an extended period of unsustainable financial growth came to an end (Yuen & Ooi, 2011). Malaysia saw annual growth rates of over 8% from the early 1980s to the mid-1990s, and from 1980 to 2007 the country's actual gross domestic product (GDP) increased at a pace of 6.1 percent per year. Power use increased more quickly than GDP due to the economy's quick and significant transition away from agriculture and toward increased industry. Primary electricity usage increased from eleven million lots of oil at a rate of 7.3% per year equal (Mtoe) in 1980 to 70 Mtoe in 2007 (Savage *et al.,* 2020). Malaysia's energy mix is primarily based on fossil fuels, with oil serving as the primary supply source till it was supplanted by gas, especially after the introduction of the Fourth Fuel Diversification Strategy in 1981. In recent years, there has been a further shift from gasoline to coal, aided by public-sector policies that favor coal for electrical power generation. Malaysia has a large supply of fossil fuels. Except for a small amount of fuel supplied by the Malaysia-Thailand Joint Development Area (MTJDA) and Indonesia's West Natural Fuel Subject, demand for oil and gasoline has been met primarily through domestic resources. Nonetheless, the need for conservation of energy and carbon emission reduction will disappear over time. The amount of CO_2 in the atmosphere has been gradually increasing as of 1958 when monitoring first started. The data reveals that around 67 percent of the world's CO_2 emissions occur now as a result of the combustion of fossil fuels.

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The world's oceans absorb some CO_2, but as pollution has surged, the oceans' consequent acidity has become more significant, causing biological and organic alterations, while rising atmospheric awareness causes global warming and climatic changes (Hov *et al.,* 2013). Although CO_2 is no longer the only greenhouse gas causing the issue, it is still the most prevalent one brought on by human activity (IPCC, 2015). A greenhouse gascalled CO_2 is created by anthropogenic activity, hydrocarbon, and natural gas (Thollander *et al.,* 2017). Climate change is caused by environmental damage caused by CO_2 emissions, which aggravate financial risks from adverse climatic events such as floods, whichcan disrupt the supply network and result in business losses (Halldórsson & Kovács, 2011). The goal of this review is to highlight the potential for energy savings and carbon emission reductions in Malaysia's industrial sector. The review is divided into several sections:

METHODS

This research aims to analyze the variables that contribute to the potential energy savings and reduction of carbon emissions in the Malaysian Industrial Sector. In order to accomplish this, a comprehensive search was conducted through reputable Worldwide databases such as Scopus, Science direct, google scholar, and Pubmed, utilizing a variety of different combinations of keywords such as greenhouse gases in Malaysia, non-renewable energy in Malaysia, Carbon emission reduction in Malaysia. In addition, references to the discovered articles were checked to ensure that the search was thorough. The inclusion criteria were access to the original article in English and a study on Carbon emission reduction in Malaysia. Access to the publication's full-text, review studies, book reviews, recommendations, protocols, letters to the editor, conference papers, thesis, and white papers, among other items, was denied. The titles of 105 peer-reviewed papers were examined to determine their relevance to the issue. After reading the abstracts, the number of articles was reduced to 30. After full-text screening by the Preferred Reporting Items for

Systematic Reviews and Meta-Analyses (PRISMA) guidelines, 30 articles were used for this review and are organized as follows:

Production of Carbon dioxide

The environment's vulnerability to carbon dioxide (CO_2) pollution from the use of fossil fuels has become one of the most urgent political and scientific challenges. The burden of the CO_2 era has substantially risen during the next 50 years (Hosseini and Wahid, 2013b). Each year, almost 30 billion tonnes of carbon are released into the atmosphere as a result of human activities (Safaai *et al.,* 2011). The major repercussions of high CO_2 levels include global warming and an increase in droughts, storms, and flash flooding, even if CO_2 has an unavoidable protection function for the world from areas frozen. Statistics show that CO_2 emissions worldwide have increased by 30% while global temperatures have increased by 0.3 to 0.6°C in recent times,(Bose, 2016). The melting of the polar ice caps and glaciers, which broadens the level of water in the oceans and sea, has caused sea tiers to rise 10-20 cm in the last century. In terms of emissions of greenhouse gases, CO_2 is the most important fuel. CO_2 has a high calorific value and is the most widely available gas in the atmosphere. Furthermore, it was previously produced easily through the influence of people, primarily through the use of fossil fuels and wood burning. CO_2 can also be viewed as a source of fuel for greenhouse gases, with various gases measured in CO_2 units. CO_2 emissions are produced as a result of the manufacture and supply of machinery, the work done in agricultural fields, the drying of grains, and the creation of electricity. Gasoline combustion is one of the main sources of emissions in industrial sectors. In addition, families that use gas combustion for home heating are regarded as substantial producers of GHG emissions. Energy-intensive enterprises like the production of iron, metal, or chemical compounds also fall into this category. Figure 1 shows historical information on worldwide CO_2 emissions between 2000 and 2013, aswell as projected CO_2 emissions from major end-use industries through 2030 (Exxon, 2015).

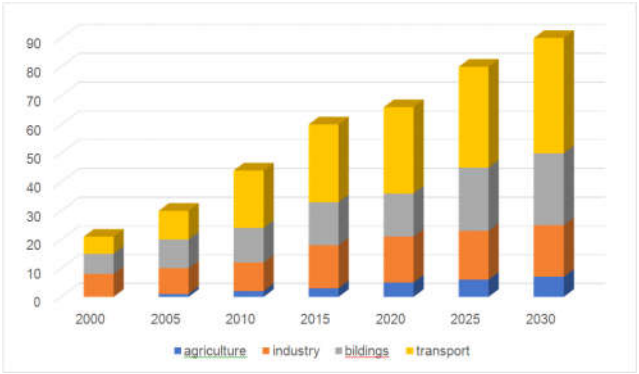

Fig. 1. Different Sector Emission (adopted from Exxon, 2016)

Malaysia and CO_2 Emission

Malaysia's transport network, electronic power production, and industrial companies have all been recognized to be the predominant origin of CO_2 emissions. According to statistics from the Asian Pacific Energy Center (APEC), Emissions from Malaysian energy consumers are expected to rise at a 4.2% annual rate, reaching 414 million tonnes of CO_2 by 2030. Aside from burning fuel, agricultural practices, disposal of wastes, and treatment of water are some of Malaysia's GHG-era assets. The Long-Range Energy Alternatives Planning System (LEAP) can be used to project the proportion of CO_2 emissions from fossil fuel-based sectors from 2000 to 2020. (Cai *et al.,* 2018). The trend of energy consumption and emission of carbon dioxide emission in Malaysia from 2000 to 2020 has been depicted in Figs. 2 and 3, respectively, using the LEAP mannequin and the accompanying formulation (Safaai *et al.,* 2011) The increasing ratio of CO_2 generation has been estimated using data such as the ratios of population growth, the rate of global income, and the level of energy demand. Malaysia's population is anticipated to grow by 2.1% between 2010 and 2020 (Shin *et al.,* 2015).

Fig. 2. The trend of Energy Consumption (adopted from Safaai et al., 2011).

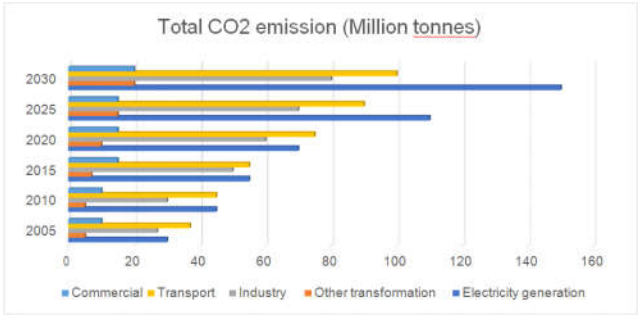

Fig. 3. Different sources in Malaysia (adopted from Safaai *et al.,* 2011).

Removal processes of CO2 in Malaysia

Some important plans must be considered to reduce the quick creation of CO_2 from fossil-fuel power plants. CO_2 capture and carbon sequestration, converting to alternative fuels, particularly biofuel and biogas, and increasing the efficiency of power plants are all good ways to reduce CO_2 emissions in Malaysia (Hashim *et al.,* 2005). Theoretical calculations show that by implementing specific measures, such as increasing the thermostat set factor of refrigerators and air conditioners and adhering to electricity efficiency regulations, the ratio of GHGs in Malaysian family functions can be dramatically reduced (Saidur *et al.,* 2017). Palm plantations and everlasting woods have played an important role in CO_2 removal in Malaysia. The CO_2 removal ratio was formerly proclaimed 167 Mt and 82 Mt through forested areas and palm plantations, respectively, and they remained Malaysia's primary CO_2 removers till now. Because Malaysian officials have embraced several strategies to extend the palm plantation in the future, this elimination tendency appears to be continuing. Table 1 summarizes some approaches for reducing GHGs through forestation planned via NRE in Malaysia (Lou & Nair, 2019).

Table 1. GHG reduction strategies planned by NRE about the forest

Objective	Reduce GHG emissions from forest					
Sub-objective	Reduction in deforestation (decrease depletion of carbon stocks)			Increase in reforestation(carbon sequestration)		
Solution	Reduction in forest-fire	Reduction of conversion	Reduction in logging	Acceleration in natural	Acceleration inforest regeneration	
		To other land uses		Forest regeneration	artificially	
Action	Improvementnt of forest fire management	Development of alternative income opportunities	Decreasenet log production volume	Decrease waste in log production	Improvementnt of land management	Plant trees

(S.E. Hosseini *et al.* 2013)

Energy mixed strategy in Malaysia

By 2030, the International Energy Agency predicts a 53 percent increase in global electricity demand. Fossil fuel is the most common source of electricity demand, with around 88% utilization. Oil, coal, and natural gas supply around 35 percent, 29 percent, and 24 percent of electricity demand, respectively. Nuclear power accounts for 5.5 percent of total global energy, whereas hydropower accounts for 6.4 percent. Because fossil fuel resources are finite and their usage is a major source of GHG emissions, the placement of RSE resources has become increasingly important in recent decades (Hosseini & Wahid, 2013a). Environmental worries over the use of fossil fuels have increased since the gases emitted during the combustion of fossil fuels can endanger ecosystems. Indeed, there is a sizable quantity of energy wasted and greenhouse gases produced when primary energy sources, such as crude oil, natural gas, and uranium, are transformed into secondary energy sources, like electricity and petroleum. Around 11% of the nation's energy needs are now met by renewable energy sources (Ong *et al.,* 2011).

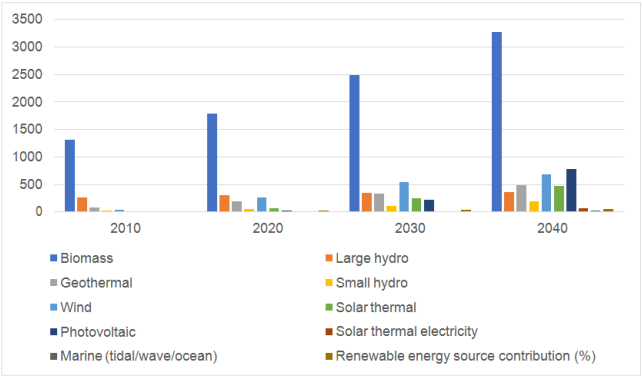

Fig. 4. Global renewable energy supply by 2040 (adopted from Ong *et al.*, 2011)

The Five-fuel expansion Strategy was put into place by Malaysian authorities in 1999 with the goals of decreasing pollution, improving efficiency, and reducing reliance on petroleum. Malaysia's main energy sources in this endeavor have been identified asoil and gas, water, sustainable sources, coal, and petroleum. Biomass could be one of the best sources of renewable energy given Malaysia's enormous wealth and forests. Natural gas just took over as Malaysia's main energy source. The greatest natural gas reserve in the world, with a daily capacity of almost a billion cubic meters, is in Malaysia. This important possibility of taken into account by the Malaysian government, which has increased the use of natural gas in the transportation sector. The government has carried out some infrastructure work, such as getting ready for routine vehicle technical inspections, getting rid of outdated cars, checking the streets, and studying and enhancing the promotion of biofuel vehicles (Safaai *et al.,* 2011).

On the other hand, the Malaysian government used to develop a fuel diversification plan because of the uncertainty in the prices of crude oil. As a result, Malaysia has made significant progress in the production and use of biodiesel. It has been determined that using palm oil-based biodiesel in Malaysia's transportation sector will significantly reduce the rate of GHG production. Furthermore, by 2015, 5.5% of Malaysia's total electricity generation was based mostly on biofuel consumption, according to policies (Tye *et al.,* 2011). Hydropower with low GHG emissions should be Malaysia's most valuable energy source. In Malaysia, electrical generation from hydropower is expected to be over 29,000 MW. However, this fantastic opportunity was not effectively used, and only around 2091 MW of electricity was created in this country. Apart from hydropower, solar power and wind power are two of the most promising sustainable electricity sources, with huge potential for producing clean energy around the world (Ab Kadir and Rafeeu, 2011). The local climate in Malaysia is perfect for the development of wind and solar energy. The daily average solar irradiation in Malaysia is unusually high, varying from 4.21 kW/m2 to 5.56 kW/m2 annually due to the profusion of sunshine across all seasons. 2011 (Oh *et al.*). The usage of this environmentally beneficial energy source is currently restricted to household settings; Malaysia reports having about 10,000 residential photovoltaic electricity devices. The most feasible of these renewable energies hasn't yet been realized, despite the effort to promote renewable energy. The utilization of renewable energy must be increased, as well as the efficiency of power production, conversion, and use, to attain fuel sustainability.

Improve Urban Planning and Promote Public Transportation

Malaysia followed industrialization and rapid urbanization strategies after winning its sovereignty in 1957, with notable dwelling and settlement expansion inthe 1970s and 1980s. To meet the growing requirements of the urban population, several agricultural and plantation properties surrounding urban centers are being transformed into new townships. Regional Development Administrations (RDAs) are designed to carry out rural urbanization initiatives in order to improve border regions, notably in developing countries Iskandar Malaysia Regional Authority (IRDA) and two main cities under the Ministry of Energy, Green Technology, and Water, Putrajaya, and Cyberjaya are leading the way as Malaysia starts to implement its road strategy. These townships will be built as municipalities that are leaders in green technology and will act as a template for the development of future townships. The economy will expand and long-term growth will be encouraged thanks to green technologies. Green technology will assist in low or zero GHG emissions, the utilization of sustainable sources of energy in urban areas, and governmental initiatives to combat climate change, all of which will help to slow down environmental deterioration. Iskandar Malaysia,

one of Malaysia's first environmentally friendly, low-carbon metropolitan developments, will be used as a case study in this essay to better comprehend. The transportation industry makes a substantial contribution to the advancement of global socioeconomic conditions due to its inherent environmental ramifications (Aziz & Amin, 2012). The objectives of satisfying transportation and improving environmental quality are frequently at odds with one another. The transportation industry is responsible for more than 25% of the world's carbon dioxide (CO_2) emissions. As a result, it makes up a sizable fraction of the emissions of nitrous oxide (N_2O), methane (CH_4), and other key greenhouse gases (GHG). The nation's general socio-economic development and the standard of living of its citizens have benefited greatly from the transportation sector's quick development in Malaysia. But as things stand, the transportation industry will be the first one to struggle with fulfilling GHG emission reduction commitments. The rise of the transportation sector is something stakeholders are worried about since it would hurt the economy as a whole and people's livelihoods. As a result, Malaysia must develop prudent policies for the expansion of climate-friendly transportation to meet its own goals for sustainability. Malaysia has set a simple objective of reducing emissions by 40% from 2005 levels by 2020. The three key sectors for achieving the target drop were emphasized as being power efficient, sustainable sources, and solid waste management. Increasing energy efficiency, particularly in transportation, will help achieve this. Numerous initiatives have been put into place to improve energy efficiency and lower GHG emissions from Malaysia's transportation infrastructure. New towns have been built using the concept of integrating land use and transport planning. Urban communities are making an effort to switch from private vehicles to public transportation. To cut the transportation sector's GHG emissions, several proposals have been made (Shahid *et al.,* 2014). Those procedures must be looked at to produce the best solutions for Malaysia. Based on a review of the literature, various methods utilized in industrialized nations to reduce GHG emissions from the transportation sector, and the results of the current study, some recommendations for streamlining the transportation sector were made.

Energy Efficient Road-based Mobility

Malaysia may place a high priority on establishing obligatory fuel economy standards, severe pollution legislation, and stringent inspection and maintenance regimes to encourage energy-efficient and ecologically friendly road-based types of transportation. To aid in the transition from personal to mass modes of transportation, larger intra-urban public transportation projects are required. To accomplish this, service transit networks' capacity, reach, and advancement can all be increased. Along with improving public transportation and reducing the usage of private vehicles, the government should encourage the use of non-motorized, environmentally friendly means of transportation in urban areas.

Management of Traffic

Traffic congestion is a problem on Malaysia's roads. It contributes significantly to Malaysia's CO_2 emissions from road transportation. The vehicle velocity components have a significant impact on the fuel usage and CO_2 emissions of motorists on a particular road stretch. Studies show that lowering vehicle speed from 40 to 15 mph as a result of traffic gridlock can raise CO_2 emissions by as much as 80%. (Panis *et al.,* 2011). Malaysia must therefore deploy traffic-calming measures for increasing traffic speeds and reduction of emissions.

Eco-driving

Numerous studies have found that driving features, such as accelerating and braking, have an impact on fuel consumption and CO_2 emissions (Barth & Boriboonsomsin, 2009). The entire people should be educated about the advantages of smooth driving. Driver education might be required to teach eco-driving. To reduce the severity and frequency of start and stop incidents, road maintenance is also important.

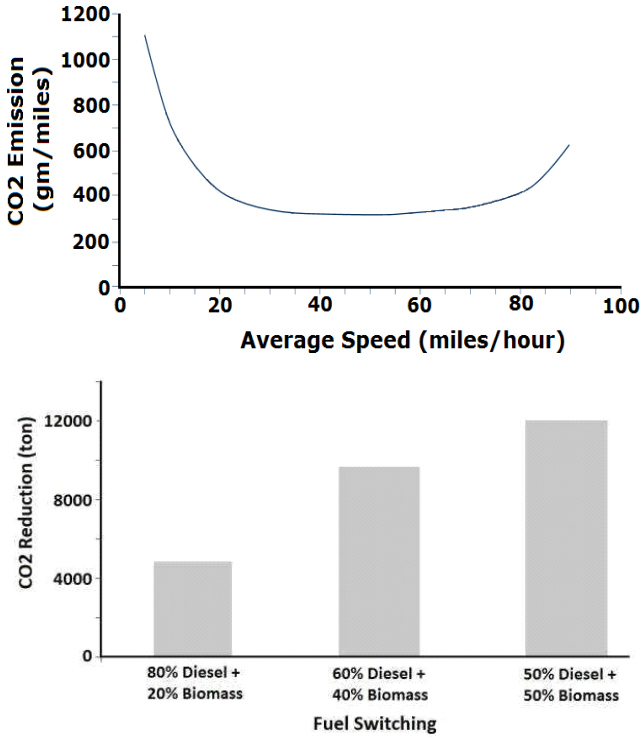

Fig. 6. (adopted from Barth and Boriboosomin 2009)

Reduction of GHG in Malaysian industries Palm oil industry

In today's energy and environmental cultures, the depletion of fossil fuels and the production of extra hazardous emissions from fossil fuel burning have become major challenges (Basha *et al.,* 2009). Environmental issues include localized weather change, glacier retreat, increasing sea levels, the effects of GHGs, and biodiversity loss that have happened as a result of the absence of an effective plan to regulate pollutant emissions in industrial sectors and transport systems (Nigam & Singh, 2011). RSE assets, such as agricultural products, livestock manure, domestic waste, and wastewater effluent, have been generated to solve these challenges. Biofuel has also been extensively used in energy generation as a fundamental biomass product. Governments in tropical countries are producing biofuels due to abundant biofuel resources, fluctuating fossil fuel prices, and the environmentally favorable quality of the bioenergy burning process (Hosseini & Wahid, 2012). It has been shown that adding biodiesel to diesel fuel significantly reduces the amount of CO_2 that industrial boilers produce (Hosseini *et al.,* 2013). Fig. 7 shows a correlation between the fuel mixture and the percentage of

CO_2 reduction in several industrial boilers powered by biodiesel (Saydur *et al.,* 2011).

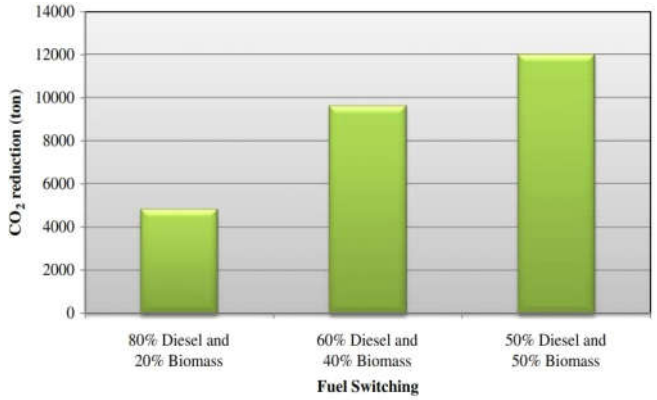

Fig. 7. Industrial boilers and CO_2 reduction (adopted from Saydur *et al.*, 2011).

The largest vegetable oil in the world is palm oil, which makes up around 35.5% of annual output (Hansen *et al.,* 2012). The cultivation of palm trees in Malaysia is mostly due to the country's ideal equatorial environment, and the development of palm oil mills is based on the improved energy technology provided by palm oil (Wu *et al.,* 2010). Figure 8 illustrates how palm oil-based biodiesel has been demonstrated to save more GHGs when compared to other biodiesel feedstocks.

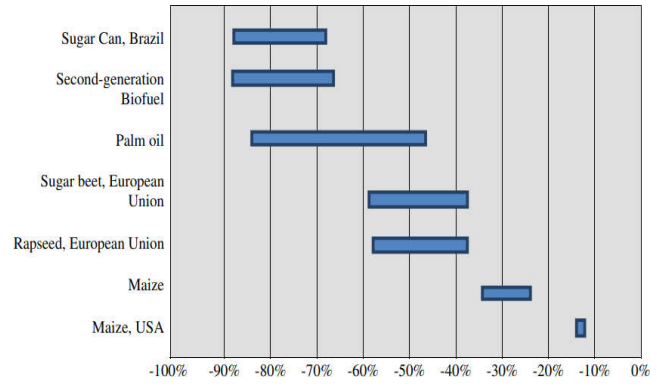

Fig. 8. Reduction in GHG emissions of different biofuelscompared to fossil fuels (adopted from Jayed *et al.*, 2009)

The most important project in the palm oil producing facility is the anaerobic process of palm oil mill effluent (POME), which produces CH_4 (Abbasi *et al.,* 2012). Furthermore, when solid leftovers like empty fruit bunches (EFB) are put into the POME, the frequency of methane generation dramatically increases. As a result of the high demand for palm oil-based biodiesel, the number of palm oil producers has rapidly increased. By contrast, 410 palm oil factories have been approved in Malaysia by 2008, up from the ten facilities that were reported to be producing a range of palm oil mills in Malaysia in 1960 (Abbasi *et al.,* 2012). 2.5–3 t of POME are released pert of crude palm oil produced using the palm oil processing method. The environment is at risk from this polluted POME, which is created during the first stage of the manufacture of biodiesel. POME can modify the environment by generating significant volumes of CH_4 and CO_2. Closing anaerobic digestion systems can be used to produce carbon emission reduction (CER) plans, per CDM requirements (Hosseini *et al.,* 2013).

Mineral and chemical production

The total amount of CO_2 released into the atmosphere by Malaysian industrial sectors was 13,690 Gg, of which 9776 Gg were produced by the chemical and mineral industries and 2797 Gg by the iron and steel industry (such as ammonia production, nitric acid manufacturing, and the usage of limestone and dolomite). Additionally, Malaysian industrial operations produced 4.28 Gg of CH_4 from the petrochemical industry and 0.66 Gg of N_2O from the manufacturing of nitric acid (the system of coke, methanol, styrene carbon black, and ethylene synthesis). Additionally, it was revealed that the amounts of HFC and SF6 were 0.11 Gg and 0.00026 Gg, respectively. Due to its dirty production process and reliance on fossil fuels, the cement industry is Malaysia's main source of air pollution. Clinker production in the cement sector results in the production of CO_2. A large amount of CO_2 is released at some time when limestone is burned to generate lime, which causes the development of clinker as an intermediate product. The amount of CO_2 produced overall dependson the type of cement used. One of the essential components utilized in Malaysian construction, steel production, pulp, and paper production, and cement production is lime. Malaysian producers of quicklime produce the most common variety. Manylime factories in Malaysia still use traditional port kilns, which can generate between 30 and 70 tonnes of quicklime per unit. Quicklime output is frequently used in Malaysia to estimate emissions of carbon dioxide from the lime sector. Technologies for combustion with reduced emissions (Hosseini *et al.,* 2013).

Conclusion

In the world coverage planning, energy supply, GHGs technology from various energy resources, and local weather exchange all play a role. Various ecosystems maybe imperiled as a result of rising pollutant emissions from combustion processes, raising environmental concerns about the use of fossil fuels in the transportation and industrial sectors. To deal with the rising rate of GHG production and the global warming phenomenon, UNFCC and KP are two international conventions that have been adopted. One of the most important consequences of Malaysia's rapid industrialization and population growth is the massive amount of pollution produced. As a result, Malaysian authorities have been actively participating in GHG removal efforts. The main preventive strategies for Malaysia's GHG increase rate are increased power plant efficiency, the use of alternative fuels in power generation, the use of RSE, CO_2 capture and carbon sequestration, the capture of biogas from MSW, landfills, and anaerobic digestions, and the use of biodiesel in the transportation and industrial sectors. Malaysia has a high potential for RSE use, particularly biodiesel production, due to its extensive palm plantations and jungles. Palm tree plantations are one of the best methods for removing CO_2 from the environment. Malaysia should also develop palm oil biodiesel because it is an environmentally friendly fuel that emits little pollution when burned.

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