IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2017, 7(3), 282-286.

EJ EconJournals

A Review on Carbon Emissions in Malaysian Cement Industry

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ABSTRACT

Cement production is an energy and carbon-intensive process. Hence, they are a noteworthy contributor to global anthropogenic CO_2 emissions. The cement industry has always been among the greatest CO_2 discharge sources with 900 kg CO_2 released with each production ton of cement. Malaysia massive amount of biogenic wastes, palms oil fuel ash, rice husk ash, sawdust ash/ash from timber. Around 0.3 million ton of palm oil fuel ash is produced every year in Malaysia, yet there are no noteworthy employments uses of these ashes. Disregarding Malaysia technical and financial benefits, till date these ashes, are only used for landfill purposes. Excessively dependent on this energy will lead to an expansion in CO_2 emission that consequently responsible for the global warming. Researchers discover by substituting fossil fuels with alternative fuels will lead to lessening in carbon dioxide emissions. Hence, we suggest that by eliminating legal, economic obstructions, CO_2 mitigation strategies can be applied on the extensive scale of the cement industry to a globally acceptable emission targets in each nation. Furthermore, the relatively small number of participants signifies that an agreement for the cement market in Malaysia can probably be reached easily between the parties in decreasing CO_2 emissions.

Keywords: Carbon Emission, Cement Industry, Energy Consumption
JEL Classifications: Q01, Q53, Q54

1. INTRODUCTION

World cement production has been growing relentlessly over many decades signifying around 2.31 Gt in 2005. Cement production addressed an extension of almost 300% from the 1970 s production levels and two-fold the aggregate production in 1990 (Zhu, 2011). Cement manufacturing, cement production is an energy and carbon-intensive process. Consequently, cement production is a noteworthy contributor to global anthropogenic CO_2 emissions (Bakhtyar et al., 2017). Furthermore, the cement industry has always been among the greatest CO_2 discharge sources as 900 kg CO_2 released to the environment for producing one ton of cement (Benhelal et al., 2013). 10 years of yearly increments of 4%, on average, was reduced to about 1% in 2012 and 2013, and further reduction in following years of 2014 as the growth in global CO_2 emissions practically slowed down, expanding by only 0.5% in 2014 (Benhelal et al., 2012). Not only CO_2 generation due to fossil fuels ignition in the cement production but carbon dioxide is also likewise delivered as by-product during disintegration reactions. According to Olivier et al. (2015), in the 2014 year, emissions from fossil-fuel raging and common procedures (production of cement clinker, metals, and chemicals) come to 35.7 billion tons CO_2 in 2015, an aggregate sum of globally discharged CO_2 transmitted of 36.2 billion tons - virtually the identical level as in 2014 (Olivier et al., 2015).

Manufacturing cement involves blending small amounts of gypsum and anhydrite with finely ground clinker. CO_2 emission is discharged into the air amid the production of clinker and directly connected with the amount of clinker created. Clinker is formed through a synthetic conversion process - called calcination - in which calcium carbonate isolated in a super-heated kiln producing lime and CO_2. According to Ke et al. (2013), the direct CO_2 emissions from the calcination process in cement making are usually called cement process CO_2 emissions. Cement production emits carbon dioxide CO_2 both directly and indirectly. In 2000, the cement industry released around 1.4 Gt CO_2 (direct and indirect), which represented for ~5% of the worldwide anthropogenic CO_2

emissions or 3% of the global anthropogenic greenhouse gas emissions (Zhu, 2011). While, utilizing blended cement can lessen the amount of CO_2 discharged says (Davis, 2002).

Malaysia mostly relies on nonrenewable energy such as fossil fuel and coal to generate the production activities yet if the economy is too dependent on this energy, it will cause an expansion in CO_2 emission that consequently responsible for the global warming (Chik and Rahim, 2014). Cement and Concrete Association of Malaysia as the Standard Writing Organization for cement has effectively required the advancement and adjustment of the new Euro standard for cement in bolstering the improvement of blended cement. In this new cement standard, an aggregate of 27 types of cement will now be allowed to produced with 26 types are blended cement and only ordinary Portland cement (OPC) being just a single of the 27 sorts of cement delivered in Malaysia. Furthermore, Malaysian Government's aspiration is to achieve a 40% voluntary reduction of CO_2 emission by 2020 in the Low Carbon Society Blueprint project toward transforming Malaysia into a Low Carbon Nation (Bakhtyar, 2017, and Yuzuru and Siong, 2013).

2. DIRECT CARBON EMISSIONS IN CEMENT FACTORIES

Direct emissions are emanations from sources that are possessed or controlled by the reporting organization. For instance, emanations from fuel burning in a cement kiln are direct emissions of the company owning (or controlling) the kiln. According to Vanderborght and Brodmann (2001), direct CO_2 emissions result from the accompanying sources: Calcination of limestone in the raw materials, conventional fossil kiln fuels, alternative fossil-based kiln fuels, biomass kiln fuels, and nonkiln fuels in cement plants. Likewise, Ali et al., 2011, summarize emissions of CO_2 in a cement industry mainly come directly from the combustion of fossil fuels and calcination of the limestone into calcium oxide. Cement is known as the "glue" that holds the concrete and is utilized extensively in construction globally (International Energy Agency, 2007). Cement industries with 25 billion tons of cement are delivered yearly everywhere worldwide and globally produced about 2.282 billion ton/year (Lai, 2015). Cement production is an energy-escalated process and energy consistently addresses to 20-40% of total production costs. The most extensively used is Portland cement type that contains 95% cement clinker. Furthermore, cement manufacturing is the most astounding potential savings for CO_2 emissions as cement records for nearly one-fourth of total direct CO_2 emissions in industry.

While cement production in Malaysia is around 20 million ton for each year and this segment of industry took about 12% of total energy in Malaysia (Madlool et al., 2011). The regular electrical power consumption of a modern cement plant is around 110-120 kWh per ton of cement (Alsop, 2005). Thermal energy represents around 20-25% of the cement production cost. Cement additives quality improver polymer (CAQIP) is created from an integrated polymer, palm oil waste for production of sustainable cement, and waste materials from petrochemical. According to (Lai, 2015), this CAQIP has substantially improved the productivity, quality, decrease CO_2 outflow, crushing and clinking energy and improved production of sustainable cement and concrete in Malaysia. In the manufacture of OPC and sustainable cement, industrial scale trial in local cement plants dosage up 0.01-0.69% CAQIP have significantly enhanced efficiency, 8.3-27.5% saving effectiveness, 24.73-86.36% clinking energy, and 7.70-21.57% crushing energy. Furtermore, the carbon dioxide and others dangerous gasses emission lessened to 21.90-90.0% by supplanting clinker with waste material such as out-spec clinker (50-100%), limestone waste (5-25%), and fly ash (25-35%).

According to Gazipur (2011), around 0.3 million ton of palm oil fuel ash (POFA) is produced every year in Malaysia, yet there are no noteworthy employments uses of these ashes as these are only dumped into environment consequently leading to disposal problem later. Similar complications have been emerged by slag, rice husk ash, and sawdust ash/ash from timber as well. A colossal amount of biogenic wastes palms, oil fuel ash, rice husk ash, and sawdust ash/ash from timber produced in the developing countries like Malaysia for instance. Industrial by-product like slag is generated both from the developed as in developing countries. These biogenic wastes that contain a high amount of silicon dioxide inamorphous form verified as pozzolanic materials that are useful in cement production. POFA is an agro waste ash that contains a lot of silicon dioxide and has high potential to be utilized as a cement substitution. In creating high-quality cement, POFA can be used as a pozzolanic material in improving durability, reducing cost with less usage of cement. Accordingly, this pozzolanic characteristic, rice husk ash to a significant degree is a reactive pozzolanic material and it is appropriate to use in lime-pozzolan blends and Portland cement as a supplement. Hence, this other industrial by-product (slag) and the biogenic waste POFA, rice husk ash, and sawdust ash/ash from timber) that accessible in Malaysia will make a critical and dynamic in decreasing the CO_2 amount. Truth be told, disregarding Malaysia technical and financial benefits, till date these ashes, are only used for landfill purposes.

3. INDIRECT CARBON EMISSIONS IN CEMENT FACTORIES

Cement production uses much electricity for raw materials preparation, cement grinding, and catering for other electrical instrumentations (Ke et al., 2013). Amid the cement production process, CO_2 is emitted by four different sources. Combustion of fossil fuel in pyro--handling unit, produces 40% of total emanations, while another 10% is in consequence of crude materials transportation and electricity generating consumed by electrical engines and facilities. While the most noteworthy proportion of emissions that about 50% is discharged in the decomposition of CaCO3 and MgCO3 to produce CaO and MgO as the core chemical responses in the process (Mahasenan et al., 2003). CO_2 outflows in cement industry mostly from ignition of fossil fills and calcination of the limestone into calcium oxide. Roughly 50% of CO_2 discharges originated from the combustion of fuels, and half of them are originated from the calcination of the limestone (Ali et al., 2011). Indirect emissions are emissions that result because of the activities of the reporting company, however, happen at sources possessed or controlled by another corporation. For instance, emissions from the generation of network electricity ran through by a cement company will qualify as indirect (WBCSD, 2011). Utilization of electricity that is generated by burning fossil fuels is considered as energy-related CO_2 emissions and transmitting CO_2 indirectly. The share of CO_2 emissions from the power utilization is 5%, and the CO_2 emissions are indirect since they are the aftereffect of the power utilization to work the plant (Zhu, 2011). This figure can vary from <1% to more than 10% as the efficiency at which it is used in the local electricity blend (Müller and Harnisch, 2008).

Furthermore, CO_2 outflows result not only from furnace operations, as well as from upstream and downstream processes, and (indirectly) from cement grinding (WBCSD, 2011). The mechanical energy required to grind the limestone, or blend the mix, is provided by electrical motors. Accordingly, the CO_2 emanations identified with the grinding are mostly indirect and referred to the use of electricity. Not only that cement production also relates to indirect greenhouse gas discharges from different sources such as external creation of electricity devoured by cement producers, production of clinker purchased from various manufacturers, transport of inputs (crude materials, fuels), and outputs (cement, clinker) by third parties and production and preparing of routine and option fuels by third parties. Cement production sometimes requires transports for the arrangement of crude materials and fuels in addition to the dispersion of products (cement, concrete, and clinker). Occasionally, clinker is transferred to another site for grinding. If the transports (such as conveyor belts, road, and rail) are carried out by independent third parties, then the related emissions qualify as indirect.

Indirect CO_2 emission reductions can be fulfilled by decreasing energy consumption in cement manufacturing (Ali, et al., 2011). Three components that determine the related CO_2 emissions (procedure efficiency, electrical engines and drive systems efficiency and the CO_2 intensity of the fuel mix in creating the electricity), the electric energy efficiency improvements can be accomplished through several approaches such as executing best accessible technologies and non-technical measures (Müller and Harnisch, 2008). Grinding processes are major power consumers in cement plants, utilizing modern highly-efficient engine or enhancing the proficiency of engine framework can bring in a remarkable decrease in electricity utilization and related indirect CO_2 emissions. The present day grinding technologies can diminish the electricity request of the crude and finishing grinding operation as well as that of coal processing for fuel planning, prompting to decreases in indirect CO_2 emissions (Zhu, 2011). Else, reduction in fossil fuel reliance also gives a chance to lessen the CO_2 emission to the environment indirectly says (Grosse-Daldrup and Scheubel, 1996, and Benhelal et al., 2013). These fuels, for the most part, include biomass residues (agricultural and nonagricultural) and waste (petroleum, miscellaneous, chemical, and hazardous). According to the International Energy Agency Statistics (2010), electricity and heat generation sector was responsible for 41% of the worldwide CO_2 emanations in 2008. It is mostly because of ignition of coal, the most carbon-intensive fossil fuel, stressing it's partake in worldwide emissions.

4. EMITTED CARBON FROM CHEMICAL REACTIONS (CLINKER)

Fuel combustion emissions of CO_2 related to cement production are of approximately in total, 8% of global CO_2 emissions (Olivier et al., 2015). During the cement production, clinker is scorched at about 1450°C. Consequently, ecological contamination and global warming are constantly expanding and, natural resources, and energies are being shrunk day-to-day.

The cement-based methodology and the clinker-based methodology are to calculate CO_2 emissions from delivering cement. The cement-based approach represents changes in CO_2 emissions in cement production by incorporating modifications (blended) to the cement manufacturing process while the clinker-based approach, calculates CO_2 emissions based on the volume and composition of clinker produced and the amount of cement kiln dust not recycled to the kiln (Davis, 2002).

These days, for the concrete production, much of the regularly utilized cement is OPC as the cost of cement are persistently increasing, and natural resources like clinker are diminishing (Gazipur, 2011). The utilization of added substances and substitutes to OPC clinker has been one of the most standout measures in decreasing the specific CO_2 emissions 0.75 of a long-term clinker proportion is desirable. F, a low clinker proportion implies the reduced CO_2 emissions as less calcination is needed in creating the cement. For Malaysia, the proportion of the clinker ratio is 0.89 (Müller and Harnisch, 2008).

Clinker production is the most energy escalated step, speaking to around 80% of the energy used in cement manufacturing. Hence, by upgrading the energy efficiency in the clinker production process can lessen the energy consumption, related expenses, and CO_2 emissions. Clinker substitution is the most financially savvy approach to reducing CO_2 emissions from cement production and has other environmental advantages. The supplementary materials cast off as clinker substitutes include blast furnace slag, fly ash from coal combustion, other natural and manufactured pozzolans. The thermal energy ingesting of per unit cement produced decreases with the expanded ratio of clinker substitutes in the blended cement (Zhu, 2011).

Experts of clinker substitutes could significantly upgrade the procedure in organizations and local governments to boost the recovery and advance the entire industrial streams particularly in heavy industries can be very favorable to supply clinker substitutes. Coal ashes with exorbitant carbon content (5% or more) diminish the cement strength, which is a noteworthy issue for quality and on the CO_2 balance, unusable coal ashes (5-20%) are proportionate to a power plant of a much lower productivity (Müller and Harnisch, 2008). In the generation of CO_2 the and internal separation process, CO_2 detachment is done inside the cement process, and almost 66% of the total CO_2 could be stored straight away without any capture process.

5. DISCUSSION

For cement fabricating, 300 Mt cement clinker (about 15%) can be substituted by slag, fly ash, and pozzolans (International Energy Agency, 2007). Fly-ash may likewise be utilized directly in the cement kiln as a replacement for clay or bauxite, and these additionally help in reducing resource consumption and CO_2 emissions. Notwithstanding, there is a range of other types of cement that utilize an assortment of clinker substitutes to reduce clinker expenses and CO_2 emissions. These different feed stocks for cement have properties like cement and therefore can be replaced for clinker either in the cement or the kiln as an option to the feedstock blend.

Dependent on the case, either the conventional or the advanced alternatives to Portland cement will prompt to noteworthy reductions of CO_2 stretching out from 20% to 80% (Müller and Harnisch, 2008). Cement is conveyed from a feedstock of clay, limestone, and sand and hence which give the four key fixings requisite of alumina, lime, silica, and iron. Another arrangement which as of now exists involves supplanting a part of the clinker in the cement with other cementations materials. Preferably such substitutes would not require any further calcination and would be incorporated after the kiln so that no thermal processing would be necessary. Blending such materials would spare 40% of the energy required for calcination, and additionally 50% of the CO_2 taking place from the reaction. In this manner, each ton of clinker substitute included would decrease the CO_2 emissions by 90% (Müller and Harnisch, 2008).

In Benhelal et al.'s, 2013, work, strategies of CO_2 reduction such as fuel and energy saving, carbon separation and storage, and utilizing alternative materials are carried out and have been reviewed by academic researchers and companies to directly or indirectly decrease CO_2 emissions in cement industry. First, utilizing waste-derived fuel in cement plant seems to be an environmental since it simultaneously reduces emissions from both cement plants and landfills. Furthermore, if waste-derived fuel is not utilized in cement process as the main or partial source of energy, it ought to be demolished by incinerators or must be sent to the landfills, generating further CO_2 in addition to CO_2 produced by the fossil fuel that has not been replaced. Second, if there should be an occurrence of energy saving approaches, moving to more efficient process for instance from wet to dry process with calciner, demonstrates the best outcomes since possibly reduces up to 50% of requisite energy and lessens almost 20% of CO_2 emissions in the process with the carbon detachment and storage, a feasible way to avoid release of CO_2. Third, the most cost-effective ways are to capture CO_2 from the flue gasses and store it away in the soil or ocean. This can reduce carbon emissions by as much as 65-70%. By reducing clinker/cement ratio with the expansion of different added substance, CO_2 emissions can be reduced substantially (Ali et al., 2011).

Industrial wastes such as fuels, raw materials, and clinker substitutes can be utilized in alleviating CO_2 emissions that root from cement plants and landfills. Regardless, economic and technical challenges can still play a remarkable obstacle against implementing such processes in the cement plant. Obstructions for the utilization of clinker substitutes remain in some markets. The legitimate systems in some developing countries require composition-based cement standards, constraining the use of clinker substitutes. This is particularly imperative since composite cement with a low clinker ratio is the second-rate in quality, but rather may have a slower reactivity and a more drawn out setting time. Nevertheless, the expanded setting time is a detriment to a blasting economy where short construction time for buildings is of great importance. Furthermore, Benhelal et al., 2013, recommend that further research need to be conducted to ensure the utilization of the alternative materials are applicable and suitable for a solid cement production, even though the alternative materials were proved chemically can be used in the cement production.

In 2006, Malaysia consumed 20 Mt of cement and had a clinker ratio of 0.89 t/t CO_2, which is higher than the world average. Hence, simulations have been created for Malaysia by Müller and Harnisch (2008), with respect the cement production by 2020 and the likelihood of restricting the related CO_2 emissions using conventional methods such as more efficient plants, the utilization of clinker substitute, and biomass-based fuels. With the assumption of the CO_2 factor of the cement industry in Malaysia was 0.77t CO_2 /=t cement in 2006 that prompted to worldwide emissions of 15 Mt CO_2 /year, and the share of biomass-based fuels in the blend can presumably be expanded to 4% or higher however it is constrained because of the nation's relatively high population density. Thus, the clinker factor can likely be brought down to 0.82 t/t. Furthermore, by upgrading existing plants and also of efficient new plants in the year 2020 in Malaysia, the average specific heat consumption of cement kilns might be decreased to around 3,250 MJ/t, hence lead to the reduction situation to an achievable decline of the CO_2 intensity to 0.68t CO_2 /t cement by 2020.

6. CONCLUSION

Cement manufacturing is an energy intensive industry consuming about 12-15% of total industrial energy use. In any case, it set up that the substituting fossil fuels with alternative fuels may play a major role in the decrease of carbon dioxide emissions. These measures will reduce environmental impacts without deterring the overall of quality cement production. Sizeable amounts of discharge of emissions into the atmosphere because of burning fossil fuels to supply energy requirements of these industries. For these reasons, particular attention is needed for the clinker production to reduce CO_2 emissions.

Although vital methodologies approach described above have high potential to subside CO_2 emissions in worldwide cement industry, however, economic and legal difficulties still play as striking deterrents against across the board execution of such methodologies implementation. Thus, by eliminating such obstructions, CO_2 mitigation strategies can be applied on the extensive scale of the cement industry to a globally acceptable emission targets in each nation. In this way, a persistent move should make by the researchers with the support from the government along with the compliance from the industry. A specific agreement could be reached to equip Malaysian plants with waste heat recovery generation (Muller and Harnisch, 2008). Furthermore, the relatively small number of participants, an agreement for the cement market in Malaysia can probably be reached between the parties to guarantee the move to lower technologies which empower the decrease of emissions.

Furthermore, in future, different sorts of blended cement will gradually supplant OPC as the main cement type in Malaysia. Both the Malaysian Government organizations and also the private part shall keep on supporting the preference for more sustainable and eco-friendly blended cement, as opposed to utilizing the ordinary OPC which generates a much higher amount of CO_2 and is less sustainable. Besides, approaches to expand further, the share of biomass must be found. The energy from biomass plays a significant role in energy demand worldwide, supplying 10% of the total energy demand (Karstensen, 2006). Hence, the proper direct smoldering of the biogenic waste can utilize as option fuel in the cement industry without issues or performance deterioration.

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