A Study of Climate Change Mitigation: Cost Effectiveness and Efficiency on Carbon Emission

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Abstract

The paper investigates in cost effectiveness and efficiency on carbon emission to mitigate climate change. It also aims to obtain the critical factors influencing on cost efficiency and effectiveness. The paper is using a quantitative descriptive research based on case- study in Cement Industry in West Sumatera. Reducing the amount of carbon emitted to the atmosphere will mitigate climate change which can be traced by cost efficiency and effectiveness. Some critical factors influencing cost efficiency and effectiveness will be observed for some periods of time to elaborate the climate change mitigation.
Limitation of the paper focuses on cement Industry in West Sumatra. Comparing the cost efficiency and effectiveness report for some periods of time is calculated to obtain empirical data.
The paper concerns on Management Accounting area and combined with the issue of climate change to provide the relationship between cost efficiency and effectiveness and climate change mitigation.

Keywords: climate change mitigation, cost effectiveness and efficiency, carbon emission

Introduction

The phenomena happening such as extreme rainfall, melting ice in north and south poles, and raising temperature are the examples of global warming. According to Fiset (2007), global warming is indicated by an increasing in temperature, land masses and oceans that can endanger the species and the earth. One of the causes is the accumulated and great amount of carbon dioxide (CO2) emitted to the atmosphere and forming green house gases (GHGs) which consequently can extinct the ecosystems. If the condition persistently occurs, the climate in all over the world will face any disturbances. This phenomenon is very hazardous and becoming an international issue for developed and developing countries.

Many organizations in the world are devoted to global warming. Since this is very crucial for our planet. One of the organizations which is concerning about climate change is the United Nations Framework Convention on Climate Change (UNFCCC). UNFCCC has some negotiations regarding climate change, and one of them is mitigation, reducing levels of greenhouse gas emissions. By 2020, Australia, as one of countries concerning climate change issues, has committed to mitigating carbon emission of five percent below 2000 levels.

In addition, there is an international agreement under the UNFCCC which discuss how governments, business entities and consumers need to change behavior and bring about a new economic environment. This protocol, known as Kyoto protocol, was released on December 11, 1997 in Kyoto, Japan but entered into force on February 16, 2005. The purposes of this protocol are to reduce global warming and to cope with the effects of temperature which tends to increase after 150 years of industrialization (Suhedi, 2005).

Therefore, there are some actions and organizations concerning about carbon emissions. Department of Foreign Affair and Trade in Australia state that the emissions must be reduced in 2010 to ensure global temperature increases are limited to below two degrees Celsius. One of the ways to mitigate carbon emission is using coal as combustion effectively and efficiently. Coal is a major combustion to produce cement. Unfortunately, combusting coal is very hazardous, since coal emits Carbon dioxide (CO2) to the atmosphere. If there is no strict regulation on how much carbon can a company emit to the atmosphere, the environment can be extinct and climatic disturbance will keep on and on. Haberl argues that the main human contribution to total carbon dioxide in the atmosphere is derived from burning fossil fuels, namely oil, coal, and natural gas. As consequence, CO2 is getting increased and GHG emissions are accumulating in the atmosphere, causing climate change and unstable ecosystems (Haberl et al., 2007).

According to the regulation of Department of Environmental Ministry, the dust emitted from coal combustion to the environment and the atmosphere cannot be in two km length (Dept. of Environmental Ministry, 2013). Thus, controlling the usage of coal effectively and efficiently is very useful since it also mitigates the climate change. Moreover, Deshpande argues that greenhouse gas emission can be caused by an individual, organization, products/services or building (Deshpande, 2010)

Based on the phenomenon and analysis described previously, the paper is addressed to investigate the cost effectiveness and efficiency on carbon emission in cement Padang industry and to seek critical factors influencing on cost effectiveness and efficiency as mitigation of climate change. The authors are eager to conduct research about climate change from environmental management accounting perspective due to the interests and concerns about the carbon emission from cement industry.

Literature Review

Cost-effectiveness is the extent to which the program has achieved or is expected to achieve its results at a lower cost compared with alternatives. Shortcomings in cost-effectiveness occur when the program is not the least-cost alternative to achieving the same outputs and outcomes. (DAC Glossary and IEG evaluation criteria). Thomas and Martin also state that cost effectiveness is a concept borrowed from the lexicon of economics, which is concerned with comparing different ways of achieving the same objective such that the most cost-effective choice will be the least costly of the alternatives being compared (Thomas and Martin, 1996).

Moreover, according to Rumble, effectiveness is concerned with outputs. An organization is effective to the extent that it produces outputs that are relevant to the needs and demands of its clients. This implies the existence of criteria by which the organizations success in this respect can be measured. In this case, if the output from the targeted goal can be achieved, it is considered as effectiveness. But somehow, organizations need to be both efficient and effective. An organization is cost effective if its outputs are relevant to the needs and demands of clients and cost less than the outputs of other institutions that meet these criteria. Organizations that pursue efficiencies to the extent that the quality of the output is jeopardized or poor may cease to be effective (Rumble, 1997).

Jones (1989) suggests that any system which seeks to make a meaningful measurement of cost-effectiveness must:

- describe the nature of the business in an objective way and establish a clear definition of the product
- determine the extent to which one is able to achieve the product aim, i.e. quantify the output of the production process, and
- establish the cost of the operation so that one can make some sort of measurement of the cost-effectiveness of the process by relating the extent of product success to the cost of achieving it.

We can describe a strategy as cost effective if it is:

- less costly and at least as effective
- more costly and more effective with an added efficacy that is worth paying the additional price for
- less effective and less costly, where the additional cost of the alternative is too high for the additional benefits provided

Council of Australian Governments or COAG's Principles and Guidelines for National Standard Setting and Regulatory Action (2004) state that cost effectiveness offers a priority ranking of proposals with the same or similar outputs or benefits, on the basis of comparative 'cost per unit of effectiveness' or 'units of effectiveness per dollar'. Also, the term cost effectiveness is frequently used to cover the case of achieving the maximum level of output for a stated level of inputs or cost. Thus, a method of delivery of a government service could be judged to be more cost effective than another when it produces more of the output for the same cost. The Report on Government Services or ROGS framework covers both cases — more output, same cost; same output, less cost — in either case the most cost effective option is that which has the lowest unit cost.

The cost effectiveness concept can be very useful where a desired outcome has been agreed, and the main issue is how to achieve this at the lowest cost. For example, it makes sense to take the lowest cost option of achieving an agreed reduction in carbon emissions (PC 2007a). This approach avoids the question of whether such action improves economic efficiency, which depends on the costs relative to the benefits of the emissions reduction.

According to Görlach, A cost−effectiveness analysis (CEA) seeks to find the best alternative activity, process, or intervention that minimises resource use to achieve a desired result. Analysts and agencies perform CEAs when the objectives of the public policy have been identified and the only remaining question is to find the least cost−option of arriving at these objectives. CEA, therefore, does not ask, nor attempts to answer, the question whether the policy is justified, in the sense that its social benefits exceed its costs. CEA is also sometimes used as a second−best option when a full−blown Cost-benefit analysis (CBA) would be desirable, but many benefits cannot easily be monetized. The cost effectiveness of a policy option is calculated by dividing the annualized costs of the option by physical benefit measures, such as animal or plant species recovered, tons of emissions of a given pollutant, acres of farmland preserved, kilometres of river length restored, etc

Cost-effectiveness analysis (CEA) is a form of economic analysis that compares the relative costs and outcomes (effects) of two or more courses of action. Cost-effectiveness analysis is distinct from cost-benefit analysis, which assigns a monetary value to the measure of effect.Cost-utility analysis is similar to cost-effectiveness analysis. Cost-effectiveness analyses are often visualized on a cost-effectiveness plane consisting of four-quadrants. Outcomes plotted in Quadrant I are more effective and more expensive, those in Quadrant II are more effective and less expensive, those in Quadrant III are less effective and less expensive, and those in Quadrant IV are less effective and more expensive (Wikipedia)

Efficiency is the extent to which the program has converted or is expected to convert its resources/inputs (such as funds, expertise, time, etc.) economically into results in order to achieve the maximum possible outputs, outcomes, and impacts with the minimum possible inputs (DAC Glossary and IEG evaluation criteria).

Rumble (1997) stated Efficiency is the ratio of output to input. A system is cost efficient if, relative to another system, its outputs cost less per unit of input. A system increases its cost efficiency when it maintains output with less than proportionate increase in inputs. Efficiency can conveniently be

divided into two components: allocative efficiency is concerned with the allocation of given resources between alternative uses in ways that maximize social welfare; x-efficiency is concerned with producing more output without any change in the allocation of inputs. It therefore focuses on inefficiencies such as overstaffing and managerial waste.

If an option is deemed to be economically efficient, it must also be the most cost effective (using the COAG definition of cost effectiveness). The converse is not always true — cost effective policies and programs need not be economically efficient. Cost effectiveness analysis is often used as an alternative to cost-benefit analysis where it is easier to estimate the desired outcomes, than it is to value them. Taking carbon mitigation as an example, a cost effectiveness analysis of policy options can identify the lowest cost approach to a particular reduction in carbon emissions. However, a cost effectiveness study cannot by itself demonstrate a conclusive case (on grounds of economic efficiency) for or against the appropriateness of a proposal, because it is concerned only with possible alternative unit costs, and not concerned with whether the total costs exceed or are exceeded by the total of prospective benefits. The beneficial effect, although achieved as cheaply as possible, may not be worth the cost — that is, it may not contribute to economic efficiency.

Going further, even if a particular policy option is the most cost effective available, and even if it does indeed produce more benefits than cost, employing it may not maximise overall economic efficiency. It may be better to abolish the program entirely and use the resources to produce something else. That is, a different use of resources may deliver a more allocatively efficient result, where consumers' wants and needs are better met. Achieving the best input mix does not guarantee that the output mix will be preferred over feasible alternatives.

The term 'cost effective' is used as shorthand for asserting that there is a net benefit (that the total benefits of an activity exceed its total costs).There is a danger of an invalid inference being drawn in this usage, namely feasible alternative — doing something else, or doing nothing. Doing something always has a cost, which is closely related to the counterfactual, as it is what is forgone as a result of undertaking a particular option. The opportunity cost is the value of the best foregone opportunity. For example, a heavy handed approach to regulation to protect consumers may impose compliance costs for the businesses (which are passed on to their customers in higher prices, back to their suppliers in lower prices for inputs, or to their shareholders in lower returns). Opportunity cost of this approach is the difference in these costs compared to an alternative light handed approach which achieves the desired consumer protection at least cost.

It is worth noting that the line between cost effectiveness and economic efficiency becomes more blurred the more broadly the policy objectives (or outcomes) are defined, and the wider the concept of costs adopted. At the limit, determining that a policy has cost effectively improved the wellbeing of society would seem to be equivalent to saying that the policy has improved economic efficiency.

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. According to US EPA, In 2012, CO_2 accounted for about 82% of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle—both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere. While CO_2 emissions come from a variety of natural sources, human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution.

The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation. The main sources of CO_2 emissions are *electricity*, a significant source of

energy in the United States and is used to power homes, business, and industry. The combustion of fossil fuels to generate electricity is the largest single source of CO_2 emissions in the nation, accounting for about 38% of total U.S. CO_2emissions and 31% of total U.S. greenhouse gas emissions in 2012. The type of fossil fuel used to generate electricity will emit different amounts of CO_2. To produce a given amount of electricity, burning coal will produce more CO_2 than oil or natural gas. *Transportation,* that is the combustion of fossil fuels such as gasoline and diesel to transport people and goods. This the second largest source of CO_2 emissions, accounting for about 32% of total U.S. CO_2 emissions and 27% of total U.S.greenhouse gas emissions in 2012. This category includes transportation sources such as highway vehicles, air travel, marine transportation, and rail. *Industry*, many industrial processes emit CO_2 through fossil fuel combustion. Several processes also produce CO_2 emissions through chemical reactions that do not involve combustion, for example, the production and consumption of mineral products such as cement, the production of metals such as iron and steel, and the production of chemicals. Fossil fuel combustion from various industrial processes accounted for about 14% of total U.S. CO_2 emissions and 12% of total U.S. greenhouse gas emissions in 2012. Note that many industrial processes also use electricity and therefore indirectly cause the emissions from the electricity production.

Carbon dioxide is constantly being exchanged among the atmosphere, ocean, and land surface as it is both produced and absorbed by many microorganisms, plants, and animals. However, emissions and removal of CO_2 by these natural processes tend to balance. Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding CO_2 and other heat-trapping gases to the atmosphere. In the United States, since 1990, the management of forests and non-agricultural land has acted as a net sink of CO_2, which means that more CO_2 is removed from the atmosphere, and stored in plants and trees, than is emitted.

Methodology

The paper is a descriptive quantitative study using cement Padang industry as the object of the study. Some quantitative approach is used to measure if there is cost effectiveness and efficiency on carbon emission. The indicator used in the research to determine cost effectiveness is the cost of coal consumption and the total of quantifiable outcome and it will be measured by the target of the company whether it can be categorized very effective, effective, and ineffective.

To measure cost effectiveness, the formula is shown below:

$$\frac{The\ cost\ of\ coal\ consumption}{the\ total\ quantifiable\ outcome} x\ 100\%$$

To measure cost efficiency, the formula is as follows:

(Current year coal consumption – Previous year coal consumption) / cement produced in current year

The data collected to measure cost effectiveness and efficiency is a primary data obtained from cement Padang industry. The period used in measuring the cost effectiveness and efficiency is from 2010 until 2013. The data will be processed by using the formula to obtain empirical data whether there is cost effectiveness and efficiency on carbon emission. In addition, some literatures and in-depth interview with cement Padang staffs will be used to determine the critical factors influencing on cost effectiveness and efficiency.

Findings

To calculate cost effectiveness, it will be shown in the table 1 below:

Table 1

Year	Coal Consumption (Tonnage)	Output	Ratio
2009	884,121	5,364,706	0,16480
2010	926,345	5,675,227	0,16323
2011	1,005,107	6,151,636	0,16339

From the table, it can be seen by using the formula previously, the reduction of coal consumption compared to the quantifiable outcome from 2009 is getting decreased. The effectiveness of coal consumption is showing decreasing. Compared among the year 2009, 2010, 2011, it can be concluded that the year 2009 is the most effective rather than 2010 and 2011. Moreover, starting 2012 and forward, PT Semen Padang does not publish the coal consumption to the public anymore since this is very sensitive and has environmental issue. ko

To calculate the cost efficiency of the carbon emission using the formula, we can see from the table 2:

Table 2

Year	Coal Consumption (Tonnage)	Output	Cost Efficiency
2009	884,121	5,364,706	-
2010	926,345	5,675,227	0.00744
2011	1,005,107	6,151,636	0.01280

The table shows cost efficiency on carbon emission in the year 2010 and 2011. The cost efficiency on using the coal consumption is still low. It means that carbon emitted from the kiln process which is consuming coal is still high. In the year 2010, there is only 0.744% cost efficiency and in 2011, there is a slight increase on cost efficiency. A low cost efficiency can be derived from some factors in Kiln process. A good quality of coal to consume will give fewer amounts rather than the medium quality.

The critical factors influencing on cost effectiveness and efficiency are divided into:

1. Uncontrollable budget
   If the company is lack of control in budget, there will be a misuse in implementing the budget a budget for production must be restricted to the cement process. No rework is done during the process because it will create additional cost for production. Therefore, the budget must be strictly confined in order to have cost effectiveness and efficiency in carbon emission.
2. Lack of skill and ability
   Workers must have an adequate skill and ability in processing any production. In cement production, the production starts from mining, milling (processing raw material), burning (kiln), last milling (cement mill) and packaging. These sequence process must follow the direction and procedures. Workers must be able to determine the quantity correctly and the process in order to make cost effectiveness and efficiency.
3. Carbon trading
   Carbon trading is one of method that one country can buy or sell carbon. It aims to reduce carbon in which one country has more carbon to produce. Carbon also gives an economic value, allowing people, companies or nations to trade it. If a nation buys carbon, it will buy the

rights to burn it, and if a nation sells carbon, it will give its right to burn it. The value of carbon itself will base on the ability of the country owning the carbon to keep it or just to prevent it from being emitted into the atmosphere. For example if country A exceeds its capacity of GHG and Country B has a surplus of capacity, a monetary agreement could be made that would see Country A pay Country B for the right to use its surplus capacity

4. NEDO (New Energy and Industrial Technology Development Organization)
   Power project, called the *Waste Heat Recovery Power Generation* (WHRPG), was the first time applied to the Indonesian cement industry. The Japanese invested funds amounting to Rp130 billion in the form of equipment. Meanwhile, the rest came from PT Semen Padang 36% (73.6 Billion) which provides the supporting infrastructure WHRPG project. Since the first time this project began in 2009 with the target of process in civil construction work in late November 2010, the mechanical and electrical construction work in late November 2011, the commissioning in the end of November 2011, and test demonstration in the end of May 2012. NEDO of Japan which Japanese government agency undertakes research and development in renewable energy and energy conservation and Cement Padang convert the combustion gas, carbon dioxide (CO2) into electricity. This technology is also expected to be applied to other cement industries in order to use energy efficiently in the future.

Conclusion

To sum up the paper, the authors have concluded that cost effectiveness on carbon emission in coal consumption in PT Semen Padang is still low from the year 2009 until 2011. In 2009, the cost effectiveness is only 16.48%, it means that compared to carbon emitted to the atmosphere is not really effective. In addition, in 2010, there is a slight decrease into 16.32%, it indicates that coal effectiveness in using coal consumption cannot be maintained at the same level with the previous year. Moreover, in 2011, the cost effectiveness is also decreasing compared to the last two years. But somehow, compared to 2010, there is an increase from 16.32% into 16.33%. We can assume that the tendency of the cost effectiveness is showing decreasing. Since the data from 2012 and forward PT Semen Padang cannot publish the coal consumption, it becomes a tendency that carbon emitted is still high.

In addition, cost efficiency on carbon emission is also showing 0.74% in 2010 and 1.28% in 2011. This is very inefficient since the number is very low. There are some aspects why cost efficiency on carbon emission cannot be achieved; one of them is the quality of coal consumption is not really good. The better the quality of coal, the less of coal is consumed in kiln department. Therefore, adding quantity of coal consumption will give impact into less efficiency

Related into what has been described previously, some critical factors are also influencing the cost effectiveness and efficiency. They are uncontrollable budget, lack of skill and ability, carbon trading and NEDO. Those factors contribute in cost effectiveness and efficiency on carbon emitted in coal consumption

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