A REVIEW ON OPTIONS OF REDUCING GREENHOUSE GASES EMISSION FROM ENERGY SECTOR

Utami Irawati
Program Studi Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam
Universitas Lambung Mangkurat Banjarbaru
Jl. Jend. A. Yani KM.36 Banjarbaru 70714
e-mail: utami_irawati@yahoo.co.uk

ABSTRACT

Climate change has influenced many sectors whereas energy sector is a crucial aspect uniquely interrelated with it. Recently, the rising global awareness about climate change and how it can affect the world has influenced the way people use and produce energy. Nevertheless, reducing the use of energy as a practical way of reducing green house gases (GHG) is not as simple as one might expect. Energy might be the main source of GHG emission. But on the other hand, as illustrated by UNEP in Global Outlook Report 2006, energy is also the main fuel of world development.

This article aims to review attempts to search best ways of reducing GHG emission to mitigate the effect of climate change from energy sector. Increasing energy efficiency and using technology to provide "clean" energy are two among those attempts. Despite the good intention of those attempts, their applications have not yet showed the expected result of a significant reduction in GHG emission. These efforts are often restrained in their implementation by a number of factors, where economic considerations come as the most dominant factors.

A continuous effort of developing technologies that support energy efficiency and clean energy provision is a crucial need. Along with it, there should also be a major reform in changing the way people behave toward energy itself.

Keywords: GHG emission, energy efficiency, alternative sources of energy

INTRODUCTION

Climate change, despite uncertainties and some scepticism about it, has surely influenced many sectors. Among those sectors influenced by climate change, energy sector is a crucial aspect uniquely interrelated with climate change. There have been strong arguments with scientific proofs that energy production, mostly from fossil-fuel burning, is the dominant contributor of greenhouse gases emission (Kerr, 2007; Quadrelli and Peterson, 2007). Being influential to climate change, energy sector is also influenced by climate change. Global awareness of climate change has influenced the way energy is being produced and used. With the scientific proof that energy production is one of the most responsible sectors of a massive greenhouse gases emission, reducing the intensity of energy might seem the most reasonable answer to reduce GHG emission. Nevertheless, the fact remains that a realistic solution is not that simple. Within the rapid development of technology, the world is now becoming more industrialized. Inevitably, energy use will keep on increasing. The interrelation between energy sector and climate change is complicated, and involve many factors. Energy might be the main source of GHG emission. But on the other hand, as illustrated by UNEP in Global Outlook Report 2006, energy is also the main fuel of world development.

This article reviews the options of reducing GHG emission to mitigate the effect of climate change from energy sector. By doing so, this essay aims to show that intentions to reduce GHG emission from energy sector are often constrained by a number of factors and considerations. Since feasibility and economic viability often come as main concerns, rapid research to develop technology in energy with the intention of cutting GHG emission from this field is an urgent need. Along with that, appropriate and regulations to support the objective of a significant reduction are also essential.

GLOBAL ENERGY USE AND HOW IT RELATES TO CLIMATE CHANGE

Since the industrial revolution, the energy use has become more intensive than before. By observing recent development in some countries, India and China for example, energy use is predicted to keep on increasing for the next few decades (UNEP, 2007). There are a number of factors that stimulate an increasing demand of energy. Arguably, population increase is one of the factors rising demands for energy (Rue du Can, 2008; UNEP 2006b). It is also a fact that there has been a change in lifestyle that creates more demand of energy. People,

especially in developing countries, often associate energy as an indicator of welfare (Chow *et al*, 2003; Moriarty and Honnery, 2008). Modern lifestyle is perceived as lifestyle with an intensive use of energy. The energy-intensive lifestyle is especially dominant in urban areas. As pointed out by Droege (2002), around 75% of energy is being consumed in cities and urban areas.

Most of the energy is used to generate electricity. In relation with electricity generation, industrial sector has become one of the most intensive users of electricity (Allen *et al*, 1990; Hoore and Watt, 1990). Besides for electricity, a significant amount of energy is also used in the transportation sector (Asmann and Sieber, 2005; IEA, 1993; Schultz *et al*, 2004). Until recently, most of the energy used is derived from fossil fuel, either from coal or petroleum. Sources of energy to generate electricity come from both coal and petroleum. As for the transportation sector, practically almost all of the energy sources are from petroleum.

Despite the rapid technology development in converting energy into electricity, there is still an uneven distribution of energy uses. Developed countries are endowed to have the access to modern sources of energy. At the same time, developed countries are also the largest consumers of energy, both for electricity and transportation sectors (Grubb *et al*, 1991; Houghton, 1997). On the other hand, people in developing countries are still using traditional sources of energy to fulfil their basic needs (UNEP, 2006b). For example, woods are still used for major fuel for cooking purposes in many developing countries.

Dependence for fossil fuel for sources of energy has made recent pattern of energy use become major contributor of GHG emission (Allen *et al*, 1990; Chow *et al.,* 2003). Conventional fossil fuels are carbon-based molecules. When conventional fossil fuel is being combusted, the bonds between carbon atoms that constitute the fuel molecules breaks apart, releasing carbon dioxide into the atmosphere. Naturally, carbon compounds have their own cycle that keeps the amount of carbon dioxide in the atmosphere at a normal level (Houghton, 1997; Pittock, 2005).

Since the industrial revolution, the natural carbon cycle has been highly disturbed from its normal condition. Industrial revolution has made industry processes developed rapidly, at the same time use energy intensively. Statistic shows that there is a very strong correlation between the amount of energy being used and the amount of carbon dioxides in the atmosphere (Hoffert *et al*, 2002). Thus, as a result of industrial development, the number of carbon dioxides released from the fuel

combustion has cumulatively exceeded the normal level. This amount of carbon dioxide and other greenhouse gases trapped in the atmosphere created the climate change effect. Based on the prediction of a growing industrialization in developing countries, then in a business-as-usual scenario, the amount of carbon dioxide in the atmosphere is estimated to reach a level that creates a severe impact on the environment (Reinstein, 2004).

Despite the prediction about the growing demand for energy until the next few decades, there is a global awareness that there should be a reform in the energy sector (Moriarty and Honnery, 2008; Rowlands, 2004; Vine, 2008). The first concern of energy saving is unlikely driven by the issue of climate change. The idea of energy saving is initially driven by the consideration about the limited fossil fuel as sources of energy (Turner, 1999). As the oil price keeps on climbing, concerns on energy use also rise, even though the rising concerns seemed to be more motivated by economic reasons (Nogee *et al*, 2002; Sachs, 2008; Scheraga, 1994). The issue of climate change has even brought more concerns on energy use. The fact that energy use strongly correlated with the amount of greenhouse gases trapped in the atmosphere has become a justification to put a reform in energy sector as a top priority to be concerned. In the light of climate change issue and its possible devastation effect on human being, it is evident that a significant reduction of GHG emission should be the main motivation of major reforms in energy sector.

OPTIONS TO REDUCE GHG EMISSIONS FROM ENERGY SECTOR

As argued before, within the fact of industrialization pattern that keeps on increasing in countries throughout the world, it would not be plausible just to cut off the use of energy without considering the factors involved in the issue of energy. Within recent circumstances, there are two major options for reducing GHG emission from energy use. The first option of cutting the GHG emission from energy sector is by increasing the efficiency in energy use (Hoffert *et al*, 2002; Jaffe *et al*, 1999). The main idea of this option is to have a more efficient process of energy conversion, lessen the amount of GHG emitted from a particular amount of conventional fuel. The second alternative for reducing GHG emission from energy sector is by shifting from conventional carbon-based fossil fuel into another sources of energy, that emit less GHG emission (Dincer, 2000; Rowlands, 2004; Turner, 1999). Solar and wind energy are among the most popular alternative sources of energy for this second option.

ENERGY EFFICIENCY, ITS BENEFITS AND DRAWBACKS IN REDUCING GHG EMISSIONS

Efficiency shows the proportion between the energy input and the energy output (Hoffert *et al*, 2002). Higher amount of energy input converted into output leads into a better efficiency. The option of energy efficiency is often described as the most feasible solution in term of economic feasibility (Brown *et al*, 2001; Vine, 2008). To some extent, it is also often claimed to be one of the most practical way in reducing energy consumption that will eventually lead to a reduction in GHG emission.

In industrial sector, energy efficiency is practiced through efficiency in the process system, avoiding loss of energy as much as possible. For example, energy efficiency is often applied in the industrial process of transferring heat and energy. Energy efficiency is also often referred as clean technology, as it also intends to reduce the amount of greenhouse gases being emitted in the process of fuel combustion within the industry process (UNEP, 2006a). For industry sector, energy efficiency offers a number of benefits if it is being applied. In monetary terms, energy efficiency relatively does not need a high capital investment. Most of the technology in energy efficiency does not require a massive replacement or new instalment of appliances. By enhancing its performance in energy efficiency, companies will also be able to reduce its cost for energy use in its production system (Brown, 2008; UNEP, 2006a). Although it appears that improving environmental performance is the main advantage of energy efficiency, there is an additional benefit of gaining a better company's reputation by being more environmentally friendly. Especially when "green" lifestyle has been a global trend, there is a tendency that consumer will likely prefer product or service from company having a better environmental reputation (Kempton, 1993).

Moving from the major scale application of energy efficiency in the industry sector, energy efficiency can also be practiced in a smaller scale. Energy efficiency can be practised in building as a medium scale application, or household sector as a small scale application (Brown, 2008; Ekins *et al*, 2002; Haines *et al*, 2007). In a smaller scale application, energy efficiency is conducted through the using of appliances designed to use less energy than regular appliances. Some states have even introduced a number of regulations, encouraging people to use these energy-efficient appliances (Brown, 2008). The regulations are often followed with some other market-based tools, such as tax and rebate, with an expectation to have a better enforcement

of this energy-efficiency regulation among the people (Jaffe *et al*,. 1999).

In addition of its application in the sector of electricity, energy efficiency can also put in practice for transportation sector. Transportation comes as the second contributor of GHG emission after electricity. Thus, reducing GHG emission from this sector would mean a reasonable decline of GHG in the atmosphere. One of major objective of research in the field of transportation is to develop engines with a more efficient and cleaner combustion process (Asmann and Sieber, 2005; Bristow *et al*, 2004). Hybrid vehicles are example of innovation in the attempt to have vehicles with less emission of greenhouse gases. Particularly for transportation sector, developing engines to have a more efficient combustion of fuel in the vehicle is not the only application of energy efficiency. Public transport should also be perceived as a means of energy efficiency, as its ability to transport more people with relatively less energy with comparison to private transport (Bristow *et al*, 2004). Thus, developing a more reliable public transports is also a means of reducing GHG emission from transportation sector.

Nevertheless, the concept of reducing greenhouse gases emission through energy efficiency still gains some critiques. One of the most frequent arguments is between the scepticism from the economists and the optimistic technologists about the cost of this option (Herring, 1999; Jaffe *et al*, 1999). Economy-based perspectives often argue that this option may become more expensive than it may seem (Hasselmann *et al*, 2003; Whitesides and Crabtree, 2007). As for the optimistic technologists, they believe that a developed research in this area will not only lead to a better and more efficient technology, but also a more affordable one (Sachs, 2008). Within a larger scale, the technologists may have their point that energy efficient will be able to come at a more affordable price for industries. However, the economic constraint apparently comes from the application at households' level. Recently, there is still a gap between the prices of energy efficient appliances and the regular ones. This gap of prices often comes at a quite significant level, that it affects the consumer's preference of the appliances (Jaffe *et al*, 1999; Scheraga, 1994). If a consumer found that there is no reasonable difference between the energy cost that they can save by using energy-efficient appliances and the more affordable price of regular appliances, the consumer will most likely choose the latter one.

Another drawback of energy efficiency as an option to reduce greenhouse gases emission is its

limitation to be developed. As demonstrated by Hoffert *et al* (2002), the curve tracking down the pattern of technology development of energy efficiency may show a trend of rapid increase in a period of time. But this trend of technology development will reach a peak point at a certain level, where the technology of energy efficiency will practically no longer be able to develop. This limitation implies that energy efficiency may come as a satisfactory option for a short-time solution.

Nevertheless, climate change must be perceived as a long time challenge (Hasselmann *et al*, 2003; Whitesides and Crabtree, 2007). Reduction of greenhouse gases emission should be set up as a strategy with long term perspective. In the light that energy efficiency may have limitation of the technology it can offer to reduce GHG emission, than reducing GHG emission solely from energy efficiency is not sufficient to prevent the destructive effect of climate change on the environment.

A pitfall of energy efficiency that should not be overlooked is the fact that energy efficiency is not actually fixing the problem of over dependence on fossil fuel. In spite of the slogan that in energy is being used efficiently, still, the main source of energy comes from carbon-based fossil fuel (Chow *et al*, 2003; Holdren, 2007). In this way then, the carbon reduction from energy efficiency will not be able to reach the expected level of carbon decline. The fact that energy-efficiency still rely on fossil fuel as main source of energy once again implies the fact that energy efficiency tends to be a short term solution. Appears as a promising alternative in saving the energy, it still ends up with the fact that fossil fuel as main source of energy is limited, and running out of availability.

ALTERNATIVE SOURCES ENERGY: IS IT REALLY AN ALTERNATIVE?

Considering the fact that the option of energy efficiency is still dependent on fossil fuel, another option that increasingly becomes a global trend is a shift toward alternative sources of energy. Most of these alternative sources are acknowledged to be renewable, based on the fact that its availability is practically unlimited (Flavin and Tunali, 1996; Grubb *et al*, 1991). Solar power and wind power are among the most popular source of energy for this option (Flavin and Dunn, 1997). Hydroelectric power has been widely used in some countries to supply energy. Liquefied fuel from biomass is also gaining more popularity to be used.

The option of shifting toward renewable sources of energy has been well accepted in global world, as it

seems a promising alternative to reduce the over dependence on fossil fuel (Rowlands, 2004). Awareness of the limited availability of fossil fuel is one of the main motivations for developing technology of generating and utilizing energy from alternative sources. With the issue of energy crisis, alternative sources of energy provide a more reliable option to enhance energy security. Dincer (2000) argues that energy security is a crucial factor needed to ensure sustainable development. Besides its relatively secure availability, some scholars highlight that the use of renewable energy emits less greenhouse gases compared to conventional fossil fuel (Rowlands, 2004; Sims, 2004). Justified by the fact of a less GHG emission produced by these alternative sources in generating energy, it appears that using alternative sources of energy is the most appropriate solution to mitigate the effect of climate change.

Another advantage of alternative sources of energy is these resources relatively have a wider spread of availability (Turner, 1999). Thus, these alternative sources might be the best option to generate electricity in remote areas.

Despite its popularity to be environmentally friendly, the option of generating energy from alternative sources is not flawless either. Economic feasibility still comes as a major concern in applying this option as an effort to reduce GHG emission (Flavin and Dunn, 1997; Grubb *et al*, 1991; Houghton, 1997; Nogee *et al*, 2002; Reid, 1990). Generating energy from alternative sources often needs a massive capital investment. Until recently, electricity production from alternative sources of energy has not yet come at an affordable level. Some countries have enforced rebates for household installing solar panel. But still, this option is not yet economically viable in developing countries, where electricity production from coal still come as the most affordable option (UNEP, 2007). In short words, alternative sources of energy need to come at a more affordable level to have a wider implementation. Regulation and market-based tools might be used to encourage the use of these alternative sources of energy (Fischer and Newell, 2004; Reinstein, 2004). But still, intensive research is urgently needed to make alternative energy sources more feasible.

Environmental impact of these alternative energy sources is also something that needs to be considered. One of the reasons for the popularity of alternative energy sources is its reputation to be environmentally friendly, since they are considered to have less GHG emission compared to conventional fossil fuel when being used. However, greenhouse gases emission shall not

solely be the only focus to be assessed in evaluating the environmental impact of alternative sources of energy (Houghton, 1997). For example, solar energy may emit less GHG emission if it is being compared with conventional fossil fuel. But on the other hand, there is still a possibility of critical water and land pollution from possible leakage of toxic material being used in its system. Furthermore, the evaluation of environmental impact should not only consider the environmental impact of alternative energy sources when being used. By using a more holistic approach, life-cycle analysis for example, it can often be revealed that alternative energy sources also emit a considerable amount of GHG emission. The life-cycle analysis of biofuel, for example, shows that greenhouse gas emission from biofuel does not significantly different from fossil fuel (Cassman and Liska, 2007; Cornu, 1990; Runge and Sauer, 2007).

Another relevant consideration of alternative energy sources in relation with greenhouse gases is the scope of carbon emission that can be reduced by using alternative energy sources. There is still a tendency to emphasize the use of alternative sources of energy merely to produce electricity (Houghton, 1997). As explained previously, transportation is also an intensive user of energy with a significant contribution of GHG emission. Within recent development, the effort to reduce GHG emission from transportation sector by using alternative energy sources is still very limited. Biofuel is often acknowledged as a potential alternative to substitute fossil fuel for vehicle (Schneider and McCarl, 2003; Tan *et al*, 2007). Nevertheless, the technology to have a total substitution of fossil fuel with biofuel has not reached the expected level. At the same time, using other alternative energy source to substitute fossil fuel in transportation sector is practically not yet feasible. Put simply, with its limitation for being applicable solely in electricity generation, the amount of GHG that can be reduced by substituting fossil fuel with alternative energy sources may not achieved the expected level of reduction.

CONCLUSION

The description above has shown that even though there has been a global intention of cutting GHG emission from the energy sector, options of doing so are still constrained by a number of factors. The application of energy efficiency and using alternative energy sources have not yet showed the expected result. Within recent condition, the level of technology development still unable to make the options of cutting GHG emission from energy sector be as feasible as needed. Considering that energy sector is one of the main contributor of GHG emission, recent efforts of reducing GHG emission from energy sector through energy efficiency and using alternative energy sources are not sufficient to mitigate the effect of climate change. Thus, along a continuous research of developing technology in this field, a major reform of shaping people's behaviour on energy is also an urgent need.

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