

Alternatives to Fossil Fuel

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Preambles

Last month I wrote about the need for the world community to seriously support actions to manage the drastic climate change that is occurring everyday. While the Worldwide Fund for Nature (WWF) has generated worldwide awareness through its annual **EarthHour** campaign, many felt that this once-a-year event is ineffective and have called for more regular activities to limit our individual "carbon footprint" and other actions to minimize emission of greenhouse gases. While participating in Carbon Offset schemes is one such alternative, each of us can also take personal actions to reduce the emission of carbon dioxide (CO₂) and other green house gases through greater understanding of how our normal daily activities are emitting these gases and take steps to reduce them or seek alternative arrangements.

Corporations, especially those who are directly involved in the power and energy generating industries or those who are major consumption of energy; eg transportation and manufacturing companies will have a major lead role to play in limiting carbon dioxides and green house gases.

Age of Industrialisation supported by Fossil Fuel

Over the past two centuries, the availability of cheap fossil fuel (coal, petroleum and natural gas) has powered the age of industrialisation that brings the current list of developed countries to where they are today. While fossil fuels have made numerous positive impacts in our daily lives and enriched the industrialized nations and their citizens, the burning of fossil fuels as we know have also seen the release of CO₂, other green house gases and pollutants at alarming proportion into our atmosphere, causing both pollution and global warming issues.

According to the forecast by the US Energy Information Administration (EIA) at <http://www.eia.doe.gov/oiaf/ieo/ieohecon.html>, overall energy consumptions will more than double from 1990 to 2030 to approximately 765 Quadrillion Btu. The emergence of China and India over the last decade will also see these two Non-OECD countries accounting for more than 27% of the world total primary energy consumptions by 2030 and with China alone far exceeding the total energy consumption of US, Canada and Mexico combined. The Climate Change Performance Index (CCPI) 2009 maintained by the GermanWatch Group (<http://www.germanwatch.org/>) showed that China and India are responsible for emitting 20.02% and 4.46% respectively of the Global CO₂ emissions in 2009. The US with less than a quarter of China's population on the other hand is responsible for 20.34% of the Global CO₂ emission and remain as one of the top 10 largest CO₂ emitters in the world together with Russia (5.67%), Japan (4.33%), Germany (2.94%), UK & Canada (1.92% each), S Korea (1.70%) and Italy (1.60%).

While coal prices have remained relatively stable over the past years, crude oil prices have seen exceptionally high volatility from US\$30 to over US\$140 per barrel. The cartel management of crude oil prices has lead to several major world events such as the Arab Oil Embargo, the invasion of Kuwait, the subsequent US-Iraq war just to name a few that are directly responsible for 5 recessions in the US since 1973. The direct dependence of foreign oil imports of many countries has also lead to the emergence of the concept of "energy security" over the past few years. It is clear that a number of the western industrailised countries would want to see the elimination of their economy dependence on crude oil due to its highly volatile prices that could drastically destabilise their economies.

Alternative Energy Sources

In his book, "Feed-in Tariffs – Accelerating the Deployment of Renewable Energy", Miguel Mendonca, writer and researcher for the World Future Council argued that development and deployment of renewable energy should be accelerated for the following reasons:

- The health and survival of humanity is dependent on the health and survival of the planet's natural resources and systems, which are being degraded and disrupted, principally by the burning of fossil fuels
- Energy independence and security of energy supply for all countries would improve overall global security and enhance the conditions for peace
- The potential economic advantages of quickly developing existing renewables markets or creating new industries are enormous

The words "Renewable Energy" is some times used interchangeably with "Alternative Energy" or "Clean Energy" but some authors are of the strong view that "Clean Energy" has a wider coverage than Renewable Energy as the latter does not include power efficiency and cleaner fossil fuels, amongst others. For our purpose, I make no distinction on these definitions and use them interchangeably. As a collection, Alternative, Clean or Renewable Energy include solar power, wind power, geothermal power, fuel cells, wave/tide power, biomass, biofuels, cleaner coal and power efficiency. Nuclear power is however excluded because of possibility of leakage of nuclear waste and release of nuclear radiation into the air.

Since the 1970s, there have been major technological developments in semiconductor technology, biotechnology, material science, nanotechnology, information technology and communications. These scientific advances form the backbone of the alternative energy industry that we see today. Instead of searching for fossil deposits in the earth crust, technology are now available for us to explore the conversion of energy from renewable sources such as solar, wind, geothermal and even agricultural crops and wastes.

Let's now look briefly at some of these alternative energy sources and their supporting technology

Solar Power (<http://www1.eere.energy.gov/solar/>)

The fuel for solar power, sunlight is free and available almost everywhere. The question is how to capture this energy and convert it into electricity at a reasonable cost. Basically, there are two ways to convert solar energy into electricity.

Thermal solar power is when the sun energy is used to heat fluid directly (usually water) and this technology operates at a much lower cost compared to the solar photovoltaic (Solar PV) approach whereby semiconductor materials are used to convert the sun's energy directly into electric current for feeding into the electricity supply grid.

While the average cost of solar power currently at US 25 cents per KWH is still way above the cost of energy produced by traditional power generation methods in the US; eg: coal (US 4 cents) and natural gas (US 7 cents), one key advantage is that there is unlimited supply of solar power.

Wind Power (Global Wind Energy Council at <http://www.gwec.net/>)

One of the key advantages of wind power is that there is no pollution or greenhouse gas emission. However, the generation of wind power is largely dependent on (1) location which can largely influence the power output which is sensitive to wind speed (2) Operating at less than full capacity since the wind turbines are much dependent again on wind speed and (3) wind power currently cost more than other conventional power sources due to the high installation costs and power transmission line costs. For some regions, wind power is not an option.

Biofuels (<http://www.nrel.gov/biomass/>)

Generally speaking, biofuels refer to a liquid or gas fuel that is derived from materials such as crops, crop waste, wood or wood products, plant oils and other similar products. The key output from these materials is ethanol which involves decomposing the glucose and other sugar contained in these materials into alcohol and CO₂. Strictly speaking, ethanol is not a clean energy source even though it gives off one-quarter less CO₂ and one-third less carbon monoxide compared to the combustion of gasoline. Moreover, ethanol produces about 25% lower mileage than gasoline and corn-based ethanol is not a particularly efficient way of producing fuel due to the large amount of resources (energy) and land required to produce 1 litre of ethanol.

However, proponents of ethanol argue that ethanol can be easily combined with gasoline as an oxygenate additive to improve combustion efficiency as well as reduce pollution. In addition for countries with agricultural sector, the ethanol industry will serve as an economic stimulus to improve the overall economy.

Biomass (<http://www.nrel.gov/biomass/>)

Typically, biomass is defined as organic matter that was once a living plant or tree and biomass power plant usually involves burning paper mill residues, timber pulps residues and even municipal solid waste. However, newer technology now enables the use of corn stalks, wheat straws, rice husks and even dried animal manure that contains a high portion of left-over plant residuals.

While the use of biomass as a source for power plant is not considered a clean source of power as it involves burning waste products and the release of CO₂ during the burning process, it is at least cleaner than burning fossil fuels. Moreover, the use of biomass provides the opportunity to use waste products as a sustainable source of alternative energy and this becomes a viable option for countries where there are agricultural sectors that regularly produces large quantities of agricultural related wastes.

Another perspective of looking at the use of biomass materials involves the understanding of the lifecycle of the plant – when the plant was alive, it converted CO₂ into oxygen during its life as a tree. The CO₂ that the plant absorbed during its lifetime can therefore be considered as an offset to the CO₂ that is emitted when the plant is burned. From that perspective, burning biomass material for energy production is considered more neutral on CO₂ emissions on a net basis.

Fuel Cells (<http://www.fuelcells.org/>)

Fuel cell is not a new invention; in fact, it was invented by Sir William Grove back in 1839 some 170 years ago. Grove knew that water can be split into hydrogen and oxygen when an electric current is sent through it (a process called electrolysis) and hypothesized that if the process is reversed, electricity and water can be produced. Grove invented the first primitive fuel cell (called gas voltaic batter) by reversing the process of electrolysis where electricity and water is produced as a by-product.

There are many key advantages associated with the use of fuel cells as an energy alternative. Amongst them are: quiet in operation, highly portable and can be used independently from the electricity supply grid, pollution free as no greenhouse gases are emitted and higher efficiency compared to other power generation systems. Another useful feature is that electricity generated can be stored and used later when electricity is needed – this feature is useful as a power back-up system as in occasions where fuel cells are used to supplement electrical supply during peak usage.

As in all cases of power generation technology, there are numerous challenges for the mass roll-out of fuel cells as an energy alternative. The foremost consideration is the issue of cost or for that matter, the high cost involved in production before large scale manufacturing can be considered. Secondly, hydrogen is not easily stored or transport and moreover, pure hydrogen gas is flammable which requires carefully handling during transportation and storage. Storage and transportation of hydrogen is also made more costly as the gas is light and requires compression for storage. While the use of fuel cells in itself is pollution free; the production of hydrogen is not necessary so. Basically, there are 2 processes of hydrogen production. Electrolysis as mentioned earlier is a pollution free process but this process is prohibitively high to make economic sense for mass production of fuel cells. The second and the most frequently used process is the reformation of hydrocarbons using natural gas. This process emits CO₂ during the reformation of hydrogen but comparatively, the emission of CO₂ is far less than other power generation systems.

Although the so-called "hydrogen economy" has been over promised, fuel cells applications in vehicles and as back-up electrical systems are taking place in various countries. Various governments also provide incentives to car dealers to import cars powered by fuel cells so as to encourage drivers to switch to a more environment friendly vehicle.

Conclusions

As pointed earlier in this article, fossil fuel (coal, petroleum and natural gas) has been the main source of energy supply fulfilling the demands of the world energy over the past two centuries. With increased energy demands from developing countries such as China and India, the world fossil fuel reserves are expected to be depleted within the next 40-50 years. Coupled with the increased environmental damages arising from emission of CO₂ and other greenhouse gases, global warming has received significant worldwide attention. The high volatility of crude oil prices and the cartel form of crude oil management have led to the heightened concern and actions by oil importing countries to be less dependent on this source of energy supply. It is inevitable that fossil fuel that has played a significant role in propelling the world economy to its current state will have to be surpassed by alternative energy sources.

Notwithstanding the current worldwide economic crisis, technological developments to improve extraction and conversion of alternative energy sources will continue with key focus on using renewable form of energy sources that are cleaner in nature. Countries such as Singapore with no natural land resources will have to look towards exploring and harnessing solar power, eg: through the use of Solar PV approach. Other options include continuing research and development of technologies to accelerate the commercialization of fuel cell applications. Developing countries with vast land for cultivation and agriculture; eg: China, India, Africa, Bangladesh, etc could exploit the use of Biomass and Biofuels as alternative energy sources. Developed countries in Europe and northern America will have to play lead roles in reducing emission of CO₂ and support projects with this objective while continuing to develop and enhance technologies to support deployment of alternative energies as replacement for fossil fuels.

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