Greening Industries; a Strategic Approach to Reducing Industrial Emissions

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***Abstract*-Adopting eco-friendly and sustainable practices in every industry is a strategic way of "Going Green" this will presents opportunities for investment, growth, savings and a healthy and sustainable future, therefore this paper gives a theoretical overview on how various industries could "Go Green" so as to make a shift towards a resource-efficient and low-carbon economy.**

Keywords-Green Growth, Low Carbon Economy, Co-generation, Waste-to-Energy, Carbon Sequestration, Green building.

I. Introduction

In developed and developing countries, the history of air pollution problem has typically been high levels of smoke and sulphur dioxide arising from the combustion of sulphur-containing fossil fuels such as coal for domestic and industrial purpose [1]. Industrial development and the use of fossil fuels have affected the world climate adversely. Africa is probably the fastest growing region in the world. Being the fastest growing region also probably means considerable increase in industrial emissions. Climate change is one of the biggest environmental challenges in world history. The shift to a low-carbon economy will change how industries operate, the products people use and their lifestyles. Business and consumers can benefit from significant savings and resource efficiency measures that will reduce greenhouse gas emissions and make climate safer for all and more conducive to growth.

All over the world, business communities are realising that to achieve global competitiveness, they have to embrace the green agenda and reduce their impact to the environment [2]. Green growth is an economic strategy that focuses on ecologically-sustainable economic progress to foster low carbon activities. A major part of green growth is a low carbon economy that refers to an economy with reduced or minimum emission of greenhouse gases and industrial emissions. This requires a shift from fossil fuels to renewable energy sources and more efficient production processes that will entail less energy per unit of output. Green industries are among the fastest-growing in the global economy. The top ten in the list are advanced biofuels, retrofitting of buildings, geothermal energy, green chemistry, green manufacturing, smart grid, solar energy, sustainable agriculture, sustainable green retailing and wind energy.

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Making the shift towards green growth presents opportunities for investment, growth, savings and healthy and sustainable future. Perspectives, mind sets and attitudes must be transformed for the country to make the shift to a Resource-efficient and low-carbon economy.

II. Method of Study

The theoretical basis of this study is to give an overview on ways in which the production industries can ~~"go~~ green" so as to reduce emissions to its barest minimum; examples will be cited in the text to show the methods industries can adopt in going green.

While it may be easy to observe and measure benefits like lower operating costs and increased market share, going green also provides intangible benefits that are equally important. Employee morale, health, and participation increases as eco-friendly improvements to factory working environments are made possible.

III. Effective Greening Practices for Industrial Processes and Factories

Making the industrial processes greener pays off tenfold in the future. Here are some of the most effective greening practices for industrial processes:

A. Make Use of Renewable Energy and Green Power

Green energy is quite literally the future of any industry. If power can be gotten from wind, solar, hydro, or biomass sources, the industries can be transformed into a more sustainable and eco-friendly operation. Many states offer tax breaks and incentives for businesses that choose this route, and such industries may even receive compensation for energy they generate and contribute back to the grid [3]. A reliable, consistent source of clean on-site energy is an excellent way to achieve true sustainability.

B. Energy-Saving Programs

A good starting point is to conduct an energy audit to see where improvements can be made. In Metro Manila, a hotel company implemented sustainable energy savings programs such as building management systems, and replacement of lightings and chillers thus allowing the company to save around 4,920,867kw-hrs of electricity or 2,952,520.20kgs. Equivalent reduction of carbon dioxide emission.

A brewery in Mandaue City has undertaken various energy conservation efforts such as reduction of light use and aircon, replacement of incandescent bulbs with energy-saving bulbs, rationalization of operations schedule to maximize usage of utilities and optimized the operation of its ammonia compressors, which contributes to 40% of the plant‘s energy consumption. Total energy conservation efforts led to savings of 8% for power and water alone or over Php18 million in-generated savings.

C. Green Building

Also known as green construction or sustainable building, is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort [7]

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

A similar concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally.

A semi-conductor company in the Cordillera Autonomous Region has the first building in the Philippines to gain LEED (Leadership in Energy and Environmental Design) certification. The company‘s building was built with respect to the sun‘s path to minimize unwanted heat gain and to maximize natural day-lighting.

D. Optimizing Water Use

A water efficiency program is a smart way to conserve water and save money. For many factories and industries processes, water bills can escalate quickly due to high levels of consumption. A food manufacturing company with factories in batangas and Laguna, explored ways to optimize the used of water in its operations and eliminate unnecessary consumption. These efforts have cut down its water consumption by 16.76% since 1997 or an average of 65,500 cubic meters of water every year. Some of the measures that the company employed include the re-use of water for various parts of its operation. Water used for sealing, cooling and even treated wastewater is collected, pumped and re-circulated for irrigation of plants and grass as well as other uses instead of being discharged as waste. See figure 3.0 below.

Figure 1.0: A food manufacturing company with factories in Batangas and Laguna recover used water from their operations and reuse that water for other purposes resulting in huge savings [2].

E. Reduce, Reuse, and Recycle Whenever Possible

Another way to save more money is to cut down on the amount of waste produced by industrial processes. Less waste means less money spent on waste removal, lower cost on raw materials, and higher levels of efficiency overall. Industries should expect a spike in productivity as they streamline their processes and eliminate excess waste. Whenever possible, the use of inexpensive post-consumer recycled raw materials and industrial participation in recycling programs when the manufacturing process is complete should be encouraged. Another common area of improvement is product packaging; the industries if possible should rethink and redesign their current packaging to get rid of any excess or waste material.

Various examples of ways of reusing industrial waste are given as follows;

F. Waste-to-Energy

Majority of the sugar refineries in the Philippines (particularly those in Cagayan valley, Pampanga and Batangas) make use of ―bagasse,” a by-product derived from sugarcane. One refinery in Leyte uses this by-product as fuel for its boilers to generate steam. The steam generated is then used to drive turbines of cane milling plant equipment and turbo-generators to produce electricity for the sugar processing plant. This helps lower energy costs of the company especially during the milling season. Also in leyte, a bio-ethanol plant utilises rice hull for running its boilers. With 100% rice hull fuel, fuel costs have dramatically shrank from whopping Php2.8 million monthly to only Php270, 000. See figure 1.0: below

Figure 2.0: A sugar milling company in Leyte utilizes bagasse to fuel its boilers to generate steam used in its cane milling plant thus lowering energy costs for its operations [2].

G. Methane Recovery

A controlled disposal facility in Metro Manila and a sanitary landfill in Rizal collect and convert methane to generate electricity. By capturing methane, which is a known greenhouse gas, environmental impacts are mitigated and the operational safety of the site is increased. See figure 2.0.

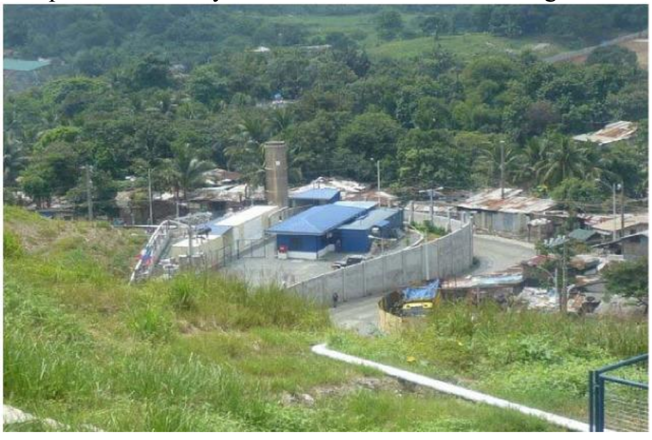

Figure 3.0: Payatas Controlled Disposal Facility in Quezon City Extracts methane gas from the old Payatas dumpsite and convert this to electricity [2].

Davao, a beer manufacturing plant recovers and utilizes methane to fire its boiler to produce steam. Annually, the brewery saves 180,000 litres of fuel or Php2.7 million using methane gas and has also earned carbon credits for this practice.

H. Co-generation

Majority of manufacturing plants of the three giant cement companies in the Philippines, reduce its environmental impact by using new forms of selected and pre-qualified waste material and by-products from other industries as either alternative fuel or alternative raw material. Co-processing of industrial and residual wastes to derive thermal energy in cement clinker production helps decrease the use of fossil fuel and carbon emissions.

A company in Cebu engaged in manufacturing various electronic peripherals likewise uses co-generation technology for its plant. Through this technology, heat that is otherwise discarded from conventional power generation is utilised to produce thermal energy. This energy is then used to provide cooling or heating for industrial facilities such as air-conditioning and machine cooling process in selected production divisions inside the plant. Recycling exhaust heat means more savings for the company which reported energy savings of 220,896kwh/month or Php1.3M monthly savings.

I. Carbon Sequestration

Carbon sequestration is capturing the carbon dioxide produced by burning fossil fuels and storing it safely away from the atmosphere.

How is CO_2 captured?

Methods already exist for key parts of the sequestration process. A chemical system for capturing carbon dioxide is already used at some facilities for commercial purposes, such as beverage carbonation and dry ice manufacture. The same approach could be adapted for coal-burning electric power plants, where smokestacks could be replaced with absorption towers. One tower would contain chemicals that isolate carbon dioxide from the other gases (nitrogen and water vapour) that escape into the air and absorb it. A second tower would separate the carbon dioxide from the absorbing chemicals, allowing them to be returned to the first tower for reuse [4]. The CO_2 in exhaust gas is separated and recovered from these gases at the emission source. Several methods of separation and recovery for CO_2 in exhaust gas are being researched and developed (see Table1.0), and some are already at a level permitting practical utilization. Polymer membrane separation is being researched and developed as a low-cost method. The membrane per se is costly, but recovery does not require a lot of energy. If it reaches the stage of practical utilization, this method is therefore expected to reduce separation and recovery costs [5].

Table 1.0: separation & recovery methods and their features

Separation & recovery methods		Features
Absorption method	Chemical absorption	The chemical reaction of a CO2 absorbent is applied to separate CO2. A large amount of energy (steam) is needed to extract the absorbed CO2. The method yields a CO2 recovery rate of 90 percent and a purity of 99.9 percent.
	Physical absorption	An absorbent is utilized to physically absorb the CO2, which is then recovered through pressure reduction (heating). The recovery rates and purity are on about the same level or slightly below those of chemical absorption (by the amine method).
Adsorption		CO2 is brought into contact with activated charcoal or some other adsorbent, and physicochemical adsorbed by its micropores. The CO2 recovery rate and purity are reportedly 90 and 99 percent, respectively.
Membrane separation	Polymer membrane	CO2 is separated by means of the difference between gas speeds of transmission through the polymer membrane.
	Liquid membrane	CO2 is separated by a membrane holding a carrier substance that selectively transmits CO2. At present, this method is at the stage of basic research.
	Inorganic membrane	Separation is effected by the surface diffusion flow arising in transmission through a porous material.
Oxygen combustion		Fossil fuels are combusted in oxygen to raise the CO2 concentration of the exhaust gas to nearly 100 percent. Testing has confirmed that this method can obtain exhaust gas with a CO2 concentration of 94 or 95 percent.
Sublimation		CO2 in gas is sublimated and recovered in the form of dry ice.
Cryogenic separation		A mixture that is a gas at normal temperature is cooled to a low temperature and separated into its constituent fractions by partial liquefaction for distillation or partial condensation.

How is CO_2 transported to its storage site?

Upon its separation and recovery from exhaust gas, the CO_2 is transported to the storage site. Table 2.0 shows the transportation methods and their characteristics.

Table 2.0: Transportation methods and characteristics

Method	Features
Pipeline	When the storage site is close to the emission source, pipelines can be used to transport the CO2 resulting from separation and recovery to the storage site in a supercritical state (in which the gas and liquid densities are the same and make it impossible to distinguish the two).
Tanker	When the storage site is far from the emission source (e.g., in another country), tankers can be used to transport the separated and recovered CO2 in liquefied form to the storage site.

How is CO_2 stored?

Upon transportation to the storage site, the CO_2 is forcibly injected into locations underground or at sea. These storage methods can be classified as shown in Table 3.0 in terms of the location and objective. With the Crude Oil Recovery and the Coal Bed Methane Recovery methods, the storage of CO_2 has Simultaneous by-products, (Oil and Methane Gas, respectively). Considering the utilization of these by-products, these methods could reduce the cost of carbon sequestration [6].

Table 3.0: Storage methods

Sequestration methods		Description	Storage capacity (worldwide)
Underground sequestration	Crude oil recovery	Injection of CO_2 into oil fields on the occasion of tertiary recovery of crude oil, to induce recovery	73.3 - 238.8 billion t-CO_2
	Coal seam methane recovery	Adsorption of CO_2 in unexploitable deep- stratum coal seams, with simultaneous recovery of methane	146.7 billion t-CO_2
	Depleted oil and gas wells	Use of the storage capacity of oil and gas fields that had held reserves of oil and natural gas; proven storage capacity	Oil wells: 366.7 billion t-CO_2 Gas wells: 1,466.7 billion t-CO_2
	Aquifers	Dissolution of CO_2 in underground salt water subject to virtually no fluctuation	At least 3,666.7 billion t-CO_2
Sea-bottom sequestration	Marine dissolution	Injection of CO_2 into the sea to dissolve and diffuse it; termed 'gas dissolution' in the case of injection in a gas state and 'liquid dissolution' in that of injection in a liquid state	3,666.7 billion t-CO_2
	Deep-sea injection	Formation of CO_2 pools in sea-bottom depressions; expected isolation period of at least 2000 years	
Biological sequestration		Sequestration by flora (plants, sea weed, vegetable plankton, etc.) through photosynthesis	Flora on land: 4.4 billion t-CO_2 per year

IV. Conclusion

The practice of —grow now, clean up later” followed in the past is no longer acceptable. Sustainable development means growing and solving economic problems in an environmentally-sustainable manner. It is protecting the environment in ways that will create economic growth and prosperity.

Governments and the private sector have a key role in ensuring that economic growth provides opportunities for the poor to engage in productive activities. The private sector is the primary driver of economic growth and employment creation.

There is a need to reduce negative environment impacts through the increased use of renewable energies and the adoption of clean and environmentally-sustainable practices. To be able to shift to green growth, the government should provide the regulatory and promotion framework and the private sector to become the engine of growth. It is important to make green growth profitable for the private sector to invest on. But to be able to achieve this, there are certain things that need to be done and these are: formulate an effective climate change policy framework; develop cost-effective implementation strategies; mobilize resources and ensure their efficient allocation; create strong incentive system and eliminate market distortions; undertake public awareness; and undertake climate change researches.

Furthermore, to ensure environmental sustainability, it is crucial to improve the way natural resources are being used. Policies must be aimed at incorporating cleaner production in national development plans and formulating action plans to promote low-carbon and resource-efficient industries. Capacities must likewise be continuously developed to promote green innovations and provide the public more environment-friendly choices.

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