

A Synopsis on the Effects of Anthropogenic Greenhouse Gases Emissions from Power Generation and Energy Consumption

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Abstract- Despite the looming difficult energy context in the majority of countries in the world, global change in environmental dignity resulting from power generation and energy consumption scenario is rapidly becoming a globally disturbing phenomenon. Stakeholders and environmental activists alike have been clamouring for adoption of reduction procedures using sustainable means because ignominious environmental practices have associated disastrous consequences. Increasing essential strategies are needed to fortify the pursuit for the reduction in the emissions from power generation and energy consumption. Therefore, this article presents an overview of the effects of anthropogenic energy generation and consumption practices capable of ejecting emissions of greenhouse gases into the atmosphere. It also endeavors to identify some greenhouse gas emission reduction and control measures.

Index Terms- Emissions, energy consumption, greenhouse gas, power generation

I. INTRODUCTION

Presently, rise in global temperature resulting from energy generation and consumption have become a very worrisome phenomenon to many stakeholders in different progressive sectors. Rise in environmental temperature and changes in related processes are directly connected to increasing anthropogenic greenhouse gas (GHG) emissions in the atmosphere [1]. This rise in temperature was vehemently argued to be generally triggered by the emission of carbon based compound from fossil fuels consumption for power generation. Figure 1 [2] shows the average global temperature rise due to emissions of anthropogenic greenhouse gases (GHGs). The curve exhibits sharp and continuous rising edges which is an indication that the global mean annual temperature have been persistently increasing over a very long period of time. By consequential effects, it has also caused the melting of ice and the rising of sea level which has led to flooding and tsunamis across the globe [3-4]. However, it was also acknowledged in several research works that global environmental stability is also subject to great threat regarding this unfolding changes if not well-checked. According to [5] change in the condition of earth climate has potential impact on agricultural production as it relates to the issues of soil

and water effects. This is because in reality, changing in the weather pattern poses threats to food production [6]. Electrical energy has conventionally being generated using fossil fuels [7] especially large blast of power supply for urban areas and industrial manufacturing activities. Fossil energy resources can be stored such that they are readily available for used. This tendency guarantees continuous energy generation security and supply stability.

Unquestionably, fossil fuel consumption has dominated the global energy production and consumption scene. Hamzeh et al., [8] reiterated that just about 10% of world energy consumption is being generated from renewable energy sources. Despite the ongoing accelerated efforts toward renewable energy development in different parts of the world, the tendency for renewable energy to completely replace conventional energy generation and consumption portfolio is characteristically uncertain and difficult because of its limited power potential. A tremendous resource is needed to harness renewable energy resources for large scale power generation. Energy stakeholders have in several fora advocated the need for sustainable development through clean development mechanism (CDM) which in essence and without dispute has been understood to be attainable by ensuring the ascendancy of renewable energy development. Beside energy generation and consumption, extractive processes of fossil energy resources is another dangerous endeavor to human societies especially the natural gas flaring. Gas flaring is the burning of natural gas that is linked with crude oil when it is pumped up from the ground [9] to the surface of the earth. Most of the observed increase in global average temperature since the mid 20th century [10-11] is very likely due to the observed increase in anthropogenic greenhouse gas concentrations [3].

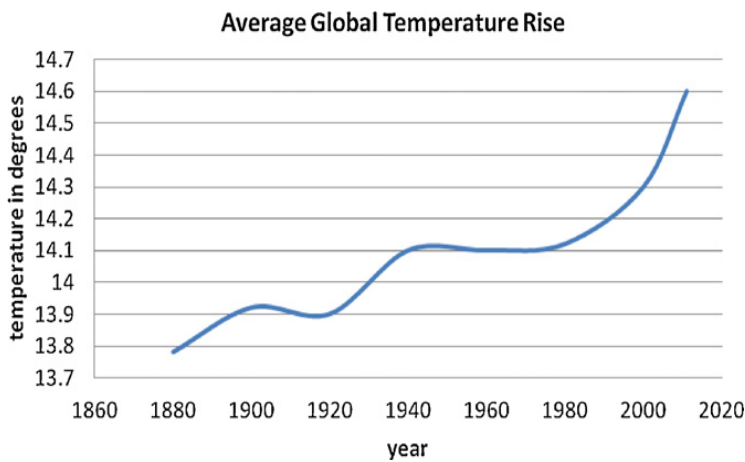


Figure 1: A curve of the average global temperature rise

II. EMISSIONS IN DIFFERENT ENERGY SECTORS

Today, energy is a stronghold sustainable prerequisite to the present global social and material development. This is because it is a requirement for meeting basic human needs, particularly heat, motive power (e.g., water pumps and transport), light and other applications such as business, industry, commerce, and public services, such as modern healthcare, education, and communication, are highly dependent on access to energy services [12]. Direct relationship exists between the absence of adequate energy services and many poverty indicators, such as infant mortality, illiteracy, and life expectancy [13]. A nation economic and physical development can be judged by the level of her energy consumption. Quest for development has brought several energy generation and consuming sectors as well as their associated environmental pollution such as emission of greenhouse gases (water vapour, methane, oxides of nitrogen, carbon dioxide and oxides of sulphur). From this outlook, energy has become a significant parameter in the daily life of all humanities. Direct reduction in energy generation and consumption as a means of reducing GHGs emissions will spell trouble for all sorts of modern development but the best alternative solution is to exploit renewable energy alternative being that they are either emission free or have characteristic lowest forms of emissions. Realistically, there are several activities contributing to global atmospheric emissions such as:

II.1 Heating and cooking emissions

Heating and cooking are mostly accomplished by the application of renewable and non-renewable energy fuels. Combustion of fuels of any kind is usually another basic source of pollution due to incomplete combustion. Today, development of cooking energy system with 100% efficient combustion have not been achieved and indoor related pollution and heat emissions have not been eliminated. Traditional stoves are not only characterized by very low energy conversion efficiencies, they also emit a large

amount of toxic elements [14] and modern energy stoves as well generate pollutants even though at minimum level. The most common emissions from traditional energy stoves are methane, unburnt suspended particles, nitrogen oxides and sulphur oxides among other toxic organic compounds. Methane is the main source of greenhouse gases among the pollutants. Methane is a basic component of biogas. Biogas is a methane-rich fuel produced from the anaerobic digestion of organic material, such as animal waste, dung and crop residues [15-17]. The heat energy loss to the environment from cooking and heating systems is another source of global temperature rise. Black carbon is soot generated from industrial pollution, traffic, outdoor fires, and the burning of coal and biomass fuels [18-19]. Additionally, in a separately electric power and heat generation systems, tremendous quantity of carbon dioxide and heat is emitted into the environment and eventually contribute to GHGs as shown in Figure 2. In some European countries, the use of combined heat and power facility is common to avoid waste to heat to the environment. Some private operators of combined heat and power plants have been rewarded in Germany [20] while in some countries government the facility is built, operate and own by the government for emission level monitoring and control. More than half of heat produced from the burning of fossil fuels for energy is release into the atmosphere. In some of the heating processes, water is used as coolant such that the return of the heated water back to large water bodies increase temperature of the aquatic environment. A transition towards optimization and exploitation of renewable gaseous fuels such as biogas and hydrogen for cooking will eventually lower the current level of emissions due to heating and cooking.

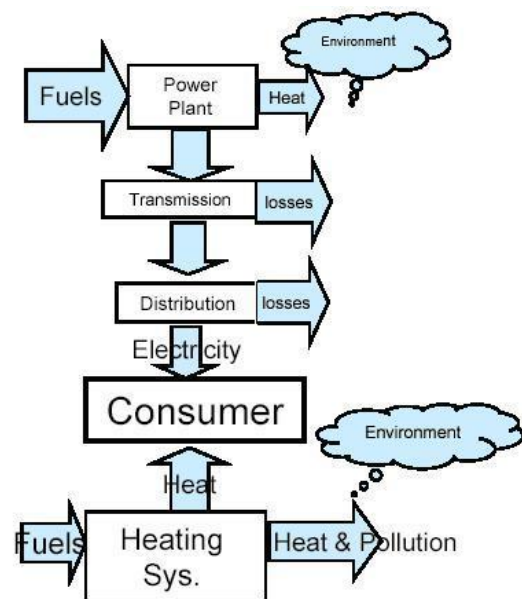


Figure 2: Structure of Separately Generated Heat and Power [21]

II.2 Automobile systems emission

The present world is rapidly migrating towards becoming transport-energy efficient especially in the urban segment. Modern transport systems are fossil fuels-based energy expended automobile mechanisms. Aviation, water and ground transports systems used varieties of carbon based fossil energy compounds with the tendency to pollute the atmosphere. Emissions from the transport sector of global economy also have some potential impacts on the global climatic changes. The current prevailing shoddy economic background in majority of developing countries where poor quality automobile systems are predominantly used is another source of air pollution. Most of these systems burn fuels insufficiently to produce black carbon which may either be due to poor engine or fuel quality. A significant application of electric vehicles and hydrogen cars will tend to reduce emissions from fossil based energy resources. Bio-fuel and biodiesel application in the transport sector can also reduce emissions [22].

II.3 Power systems emission

Electricity generation can be achieved using various energy resources. Figure 3 shows the combination of different energy resources for electricity generation in the United States of America in 2009. In modern electricity generation and consumption, fossil power sources are more used to provide electrical energy due to cheapness and their ability to generate large power. To this effect, fossil power plants are more common today. Fossil power plants are electric power generators that are used to burn fossil fuels to generate electricity for consumption. Major fossil fuels widely used today are petroleum, coal and natural gas. Operation of fossil fuel power stations give-off carbon dioxide which is a major source of greenhouse gases (GHGs) according to the harmonize opinion of energy and environmental pollution researchers.

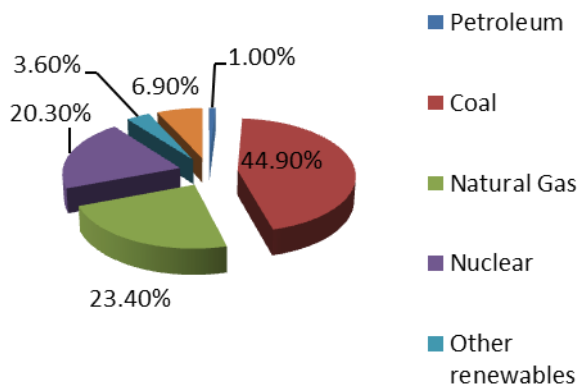


Figure 3: Sources of electricity in the United States (2009) [23]

GHG emissions associated with the provision of energy services are a major cause of climate change [3]. Operations

of modern electric power system generators are based on fossil fuels combustion with overall effects on the biosphere and built environment. In large and semi-urban settlements, there are many activities that needed energy for operations. In every part of the world, demand for electrical energy is highly on the rise due to increase in manufacturing, construction and household and institutional activities. In developing countries, a lot of private businesses supplement their shortage of electricity with petrol and diesel fuel generators to provide the required energy. Tremendous quantity of smoke particles as well as other harmful compounds are expelled from the exhaust pipes of these generators and escape freely into the atmosphere. Without any benefit of doubt, the exhausted wastes are the basic source of greenhouse gas. In many developing countries of sub-Sahara Africa fumes from private individual generators have been reportedly killed many due to careless indoor operations.

In a coal power plant, emissions of particulate matters are another rampant tendency. These are tiny particles release during combustion of coal in a coal-fired power plant. In most modern power plants operating on coal as fuel, electrostatic precipitator, cyclone collector and construction of bag house have been used to remove particulate matters. Other method employed as an effort directed towards the particulate matters emission reduction is the design of Integrated Gasification Combined Cycle (IGCC) power plant. This power plant makes use of synthesis gas produce from a chemical reaction between coal and water to generate electricity. IGCC operates in such a manner that particulate matter pollutants is removed from the synthesis gas used for power generation and the thermal exhaust gases generated as by-product is used to produce steam to operates a steam turbine power plant.

In nuclear power plants, dispersed radioactive materials could be concentrated in the atmosphere such that living organism may lose the ability to tolerate their effects. Most nuclear power plants are well prevented against emissions of radioactive fallout materials. Nevertheless, contact with a significant amount of radioactive trace materials could result into change of genes and chromosomes a phenomenon known as mutation. Apart from mutation effect, several other damages could be caused by the presence of radioactive materials in our environment. A good number of the world nuclear power stations are owned by the advanced countries of the world especially United Kingdom, Canada, Russia, Japan, Germany and France. India and Pakistan are prominent among the few developing countries operating nuclear power plant.

Global political power play have seriously restricted active participation of developing countries in the construction and operation of nuclear power station especially the middle-eastern countries. This is due to the concern that the possession of such technology may advance into proliferation of weapon of mass destruction (WMD) and global terrorism. Nuclear power plant is being operated at an affordable cost today but conventional risks connected with the power plant is catastrophically unique as witnesses in Chernobyl and Fukushima. Although, most of the nuclear

power accidents can be traced to human errors and the need to digitally automate the power plant for adequate reliability and safety is inevitable. This will indeed avoid cascaded failures and reduce errors related to human factors such as forgetfulness.

III. EFFECTS OF GREENHOUSE GAS EMISSIONS

III.1 Health risk

Emissions of greenhouse gases mostly pollute the quality of air. Clean air is prerequisite for sound and healthy living. Air pollution usually result in different cases of premature death especially among children are aged people. Several health related problems was said to have been orchestrated from global climate change. Infectious disease like malaria [3] has been reported. Indoor air pollution has been another rampant situation among the developing world due excessive combustion of solid biomass resources for energy consumption. Indoor air pollution from solid fuels is the cause of very severe health problems [14]. Diseases like eyes cataracts, tuberculosis, asthma attacks and lower birth weight [24-25] are caused by indoor air pollution. Majority of illness related to cardiovascular and acute lower respiratory infections [24,26,27-28] are elicited by indoor air pollution.

III.2 Natural ecological destruction

Ecological destruction has been one of the most visible effects emissions of greenhouse gas and exploitation of energy resources from the human environment. In urban areas, electricity generation and fossil energy consumption are predominantly used by larger percentage of the population compare to the situation in rural areas. Less polluting energy resources is essential to lower emissions of GHGs. In many rural communities with difficult access to electricity from the traditional grid expansion, renewable energy resources have been used to as the main source of energy production. This practice has been very helpful to the environment as per very low related emissions from the renewable energy resources but on the contrary has pronounced effects on the destruction of the ecosystem e.g. continuous deforestation. Marine ecology is not spared in the existing level of greenhouse gas destruction. Increased level of carbon dioxide in the atmosphere has also resulted to oceanic acidification [29] and decline in the amount of dissolve oxygen with adverse effects on aquatic life [30]. In addition, power generation and energy consumption have thoughtful impacts on aquatic and terrestrial habit due to toxic chemical from coal mining and oil spillage. The duos have direct causes of land and water pollution because the harmful chemicals can directly be leached into water bodies with adverse effects on waterways and useable waters.

III.3 Natural ecological destruction

Global warming potential is the capability of greenhouse gas to retain heat and light in the atmosphere and thereby increasing the global ambient temperature. Change in global warming potential (GWP) has been an unfolding issues since the beginning of the era of industrial revolution. Power generation and energy consumption are artificially induced mechanisms which increases the global warming potential. It cannot be argued that some natural mechanisms decrease the GWP by some accepted removal processes such as afforestation for carbon stocking, but aggressive use of energy for rapid development have in recent offset the removal scenarios. Besides, excessive uses of wood for energy have also influences environmental degradation and increase the concentration of carbon-based compounds in the atmosphere which is the fundamental cause of greenhouse gas pollution.

IV. REDUCTION AND CONTROL MEASURES OF GREENHOUSE GASES

Reduction of GHGs is central to all nations because the brunt of the problem is global and no one country or group of countries can provide its own remedy [3]. This is why international and regional cooperation are more sought-after and have been well advocated for in the comity of global atmospheric sanity. In respect to this struggle, United Nations Framework Convention on Climate Change (UNFCCC) recently came into effect to deal with the global climate problem [31]. This was executed in the form of international agreement comprising different countries across diverse regions to lower the dangerous concentration of anthropogenic GHGs in the atmosphere.

IV.1 Clean development mechanism

Clean development mechanism involve massive deployment of renewable energy technologies for power generation and carbon dioxide sequestration to promote the concept of sustainable development. Beside the GHG mitigating potential of renewable energy resources, energy security guarantee is swiftly becoming a reality with the exploitation of different renewable energy resource. Clean development mechanism is a fundamental idea of Kyoto Protocol under the canopy of the United Nations Framework on Convention on Climate Change (UNFCCC). Developing countries are more actively involved in the development of renewable power generation in line with the proposed CDM. In 2009, developing countries hosted 53% of global RE power generation [32]. Initial idea behind the institution of CDM is to strategically lower the level of emissions due to energy generation and consumption to a sustainable intensity. However, it was envisaged that emission reduction mechanisms will be financed by the industrialized nations whereby the fund will be given to developing countries as sponsorship for renewable energy programs. After a decade and more, a good implementation result is yet to be seen and gain in the global pace of renewable power exploitation is not in line with the realistic and expected level of developments.

IV.2 Green energy portfolio standard

Green energy is a type of energy produced conventionally with a reduced amount of negative environmental impact. Green energy is sometimes called renewable energy. Renewable energy application has become an essential ingredient with significant role in the expedition for GHG reduction and increasing the chance for sustainable development. Many countries have introduced and finance green energy programs to generate and consume power with minimum pollution. Green energy portfolio standard (GEPS) involves the uses of regulation to boost generation and consumption of energy from greener sources with the minimum rank of pollution propensity. In some countries where green energy portfolio standard is strongly advocated, compulsions are placed on electric power generation companies to provide certain percentage of the national electricity demand from renewable sources as a strategic measure to lower emissions. Intergovernmental Panel on Climate Change (IPCC) direct countries to communicate their emissions from all sorts of energy related activities. Advocates of GEPS listed the benefits among which are innovation, pollution control and competition can eventually lower the per unit price of renewable power. Sustainable development of green energy can provide numerous environmental benefits alongside fossil resources conservation for far future generations.

IV.3 Financing low carbon energy

CO₂ emission resulting from the combustion of petroleum products contributes substantial quantity of greenhouse gas to the atmosphere [33]. As a critical factor towards development, a secure access to modern energy is essential for development. With the current global acknowledgement on the need to reduce emissions from energy, financing low carbon energy can be used as a strategy to reduce greenhouse gas emissions. Many financing initiatives exist for funding energy projects [34] but financing low carbon projects is indispensable especially in countries where oils are the major source of income and energy production. Driven an economy by a low-polluting energy technologies reduces the vulnerability of the human environmental sustainability. This envisioned low carbon economy can be harnessed by unlocking the untapped renewable energy resources potential. Optimization of renewable sources for energy application provides noteworthy opportunities to spread out and upgrade the energy infrastructure especially in the rural communities due to their diverseness. Via this strategic measure, the solution to energy poverty in developing regions can be provided by decentralization of the renewable energy systems. In some countries, emissions trading scheme (ETS) through carbon taxation is already implemented to control and monitor emissions. Carbon taxation has been adopted in United Kingdom, Denmark, Finland, Norway, Sweden, the Netherlands

and Canada and under debate or proposed in another places, including in the EU, Japan and South Africa [14]. This is due to the fact that there is rising profile in GHGs due to energy use. In 2005, as much as 68% of total anthropogenic GHG discharges were estimated from energy related-activities [35].

V. CONCLUSION

This study has shown that activities related to power generation and energy consumption has associated emissions with potential to influence greenhouse gas which is the main source of impending global warming. In reality, anthropogenic greenhouse gas emissions from energy activities are greater than the greenhouse gas emission from other human activities. Essentially, the study also advocated the need to strategically tackle GHG reduction to prevent the sanctity of the global environmental distinction for sustainable development and biodiversity interaction. Finally, it supported the need to increase renewable energy consumption to help in dealing with problems of energy security, energy control and health related problems.

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