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MITIGATING CLIMATIC CHANGES THROUGH EMISSION REDUCTION TECHNOLOGY

IR Ilaboya [1] and ST Wara [2]
General Abdusalam A. Abubakar College of Engineering, PMB 0006, Igbinedion University Okada, Edo State, Nigeria

ABSTRACT

This paper considers the role of technology in emission reduction strategies. This includes carbon sequestration, use of renewable emission- free and environmentally friendly energy sources, energy conservation efficiency, atmospheric variability studies modeling of mixing height and the use of biofuels [bioethanol and biodiesel] as measures to check the continuous release of poisonous gases into the environment. Data on variations in temperature according to height for a particular environment was computed for three weeks. Average readings were used to model the mixing height for that particular environment. This model aimed to determine the most effective height stack to guarantee maximum dispersion of any plume released around that particular environment. Attempt was also made to analyse the negative impact of gaseous emissions in an immediate environment. Some of such negative impacts discussed in this research paper include: Stratospheric ozone layer depletion, the issue of acid rain deposition and the greenhouse effect. The focus is on achieving a healthy and emission-free environment.

Keywords: Greenhouse gases, ozone layer destruction, global warming carbon sequestration, mixing height, atmospheric variability, renewable energy.

1. INTRODUCTION

Energy plays an important role in social and economic life. So many, especially the rural poor, face a high degree of deprivation in terms of access to modern energy services, hence they are deprived of opportunities for economic development and an improved standard of living. Report on "Towards a Sustainable Energy Future", states about 1.6 billion people have no access to modern electricity; if good policies as to how affordable and reliable energy can be created are not put in place, 1.4 billion will still lack electricity and energy access by 2030, thereby conflicting the global vision of eradicating poverty by that date, since energy is a vital tool in that direction. Energy issues in developing countries are often ignored and the issue becomes even more pathetic when the energy trend in developing countries is traced. Rural dwellers suffer a high degree of deprivation when it comes to issue of energy services and utilisation. Four out of five people without electricity live in rural areas of the developing world, mainly in South Asia and sub–Saharan Africa. The consequences of this deprivation is, in an attempt for rural dwellers to meet their huge energy requirements, they resort to uncontrollable burning of fossil fuels [kerosene, gas and coal], coupled with extreme dependence on biomass [wood] resulting in a continuous release of greenhouse gases [SO_2, CO_2 and methane] into the atmosphere. The consequences are referred to as the precursor to global Armageddon, to others as mere hype; whatever it is, the truth lies in-between. The international community has joined in recognition of the growing threat from global climate change. Under the 1992 international Kyoto Accord, developed countries were required to scale down greenhouse gas emission to 1990 levels by 2000. Under the auspices of the United Nations Framework Convention on Climate Change [FCCC], the parties are charged with designing a plan for significantly reducing carbon dioxide and other greenhouse gas emission post–2000. Greenhouse gases such as carbon dioxide, methane and nitrous oxide, exist naturally in the atmosphere, but are also released in great quantities as a result of human activities. Scientists predict that, given current trends of increasing emission of most greenhouse gases, atmospheric concentration are expected to increase through this century and beyond. The debate over global climate change has focused on both naturally occurring greenhouse gas emission as well as emission generated from human activities, including the burning of fossil fuel, land use change and agriculture. The International Panel on Climate Change summary report indicates "the anthropogenic emission of such gases has contributed more than 80% of recent climatic change. The fact still remains that, if these issues are not properly addressed, man has no option than to face a resulting catastrophe of greenhouse gas emission. Following this assertion, it will do humanity well to think of a quick and urgent solution. This paper focuses on change in man's attitude as the most important. There are two ways: first is to educate man on the potential threat from global climate change, and another is the adoption of new technology that will reduce emissions. Discussed in this paper are; the pre and post resultant effects of global warming and greenhouse emission, coupled with technological concepts capable of reducing emission and finally, the overwhelming role of government in ensuring these problems are given immediate attention.

2. ATMOSPHERIC VARIABILITY STUDIES

This study explains the effects of atmospheric stability on the vertical dispersion of pollutants in the atmosphere. Pollutants once released into the atmosphere are largely affected by the degree of instability of the atmosphere. Atmospheric stability refers to variation in temperature according to altitude. This variation affects the vertical mixing/dispersion of the pollutants. Mathematically, this variation is define by the linear relationship between the dry adiabatic lapse rate (DALR) and the ambient lapse rate (ALR)..

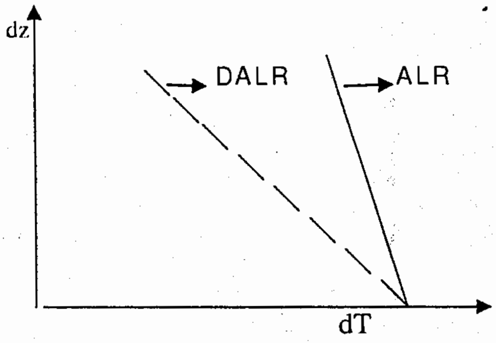


Figure 1: ALR < DALR

Under this condition, there is a stable atmosphere also known as the sub–adiabatic condition, which do allows for vertical dispersion of pollutant once it is released into the atmosphere, thus suppressing pollutants and concentrating them at ground level, thereby causing serions ground level pollution.

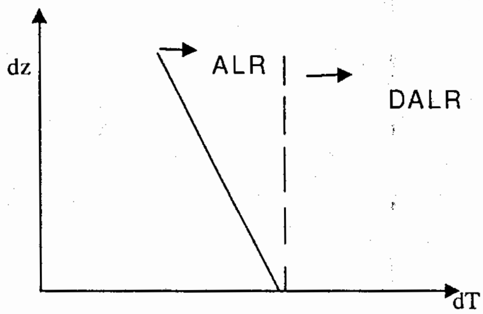


Figure 2: ALR > DALR

Under this condition, there is unstable atmosphere also known as the super adiabatic condition, which allows for vertical dispersion of pollutant once it is released into the atmosphere. With regard to local or regional air quality, a condition of atmospheric unstability is preferred to a stable condition.

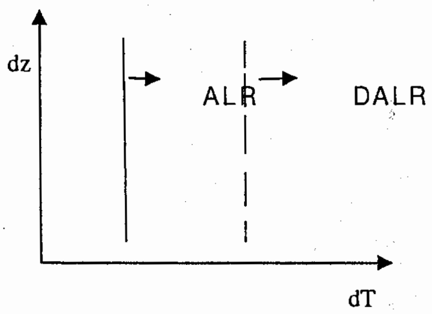


Figure 3: ALR = DALR

This kind of atmospheric condition neither supports nor suppresses pollutants once they are released into the atmosphere.

NB:

ALR: The actual measurement of the variation of temperature with altitude. Mathematically, it is given as $[\frac{T_2 - T_1}{Z_2 - Z_1}]$ For this research, an infra-red temperature meter [see Figure 1] was used to measure the temperature variation in a 45m telecommunication mast.

DALR: This is the reference indicator based on the assumption that temperature decreases with altitude. The actual variation is 1℃ reduction in temperature for every 100m.

A clear unerstanding of this behaviour will helped to explain the results the model derived to calculate the mixing heights of a predetermined location. The graph obtained from the model was checked against the three cases already discussed to discover the nature of the environment and how to define the final height of any stack placed in such an environment.

3. DATA COLLECTION AND ANALYSIS

Data of altitude versus temperature was collected three times a week for three weeks in March 2009. The average reading is shown as:

Table 1: Temperature Vs Altitude

Altitude (m)	0	10	20	30	40	45
Temperature (T^{0c})	30	29.5	31	31.5	30	28

The highest temperature for the month was 34℃.

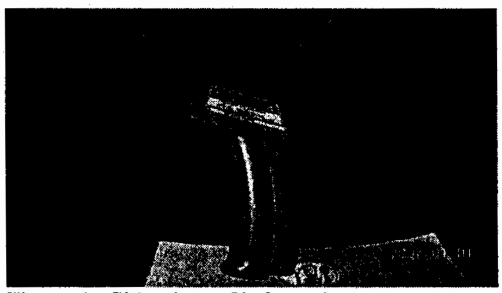


Figure 4: Side view of infra-red temperature meter

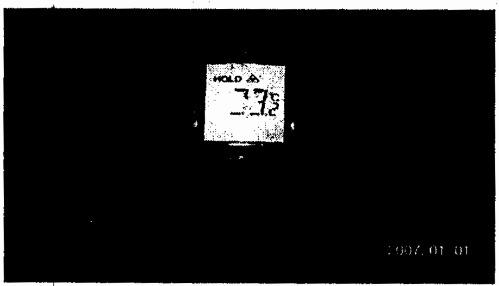


Figure 5: Back view of infra-red temperature meter

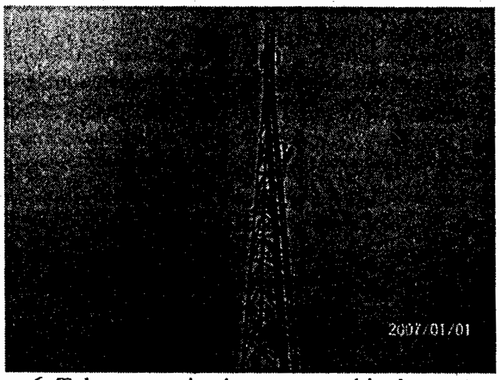


Figure 6: Telecommunication mast used in data collection. [45m: under construction]

3.1 STATISTICAL ANALYSIS OF DATA

Statistical hypothesis involving testing the coefficient of correlation was employed to ascertain data validity.

Table 2: Coefficient of Correlation (r) Table

X	Y	XY	X^2	Y^2
0	30	0	0	900
10	29.5	295	100	870.25
20	31	620	400	961
30	31.5	945	900	992.25
40	30	1200	1600	900
45	28	1260	2025	784
∑=145	∑=180	∑=4320	∑=5025	∑=5407

The coefficient of correlation (r) was calculated to be [0.14].

At 99% confidence interval, with a degree of freedom equal to 6, the critical value was found to be [0.92]. Since the value of (r) was less than the critical value, it was concluded that there was a slight linear correlation between temperature and altitude. This conclusion is correct since the effects of wind speed and wind velocity profile as a factor. Data is certified correct and may be used for modelling.

3.2 ATMOSPHERIC STABILITY MODELLING

The model aimed to explain the nature of atmosphere around the vicinity of the mast and to predict the behaviour of any pollutant emitted around it. For this model two temperature readings and the corresponding altitude were used to compute the value of the ambient lapse rate (ALR). The resultant value was then multiplied by 100 and plotted on a linear graph to ascertain the nature of the atmosphere and the corresonding stability at that location.

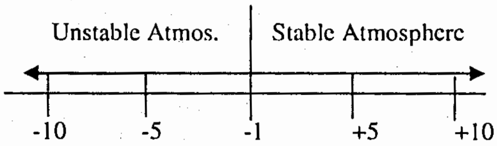
Table 3: Atmospheric Stability Table

Altitude (m)	Temperature (T^{0c})
10	29.5
30	31.5

$$ALR = \frac{dT}{dz} = \frac{T_2 - T_1}{Z_2 - Z_1} = \frac{31.5 - 29.5}{30 - 10}$$

$$ALR = 100 \times O.1 = 10$$

This value was represented, on a linear graph:



The model disclosed the location from where the data was collected, was a stable atmosphere (see Figure 1). The implication of this, is that any pollutant released in that location would be suppressed and could not be dispersed effectively, thus causing serious pollution problems.

The only solution was to determine the mixing depth, that is, the effective height of any stack placed in such location to permit effective dispersion and dilution of pollutants.

3.3 MIXING HIEGHT MODELLING

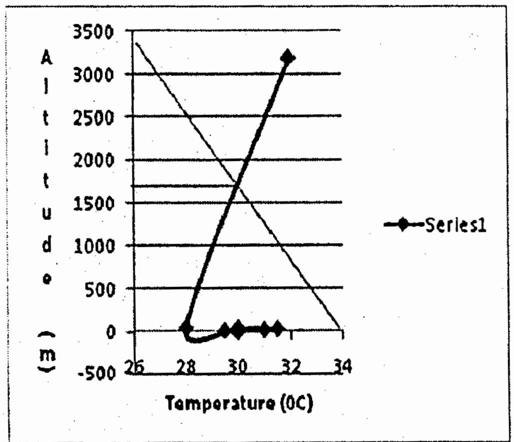


Figure 7: Graphical variation of temperature with altitude

The result indicates the effective height of stack to allow effective dispersion of any pollutants as 1700m. Any stack below this height would lead to ground level pollution. A model of this kind will enhance the effecive mixing and dilution of pollutants and should be strictly adhered to during the design and construction of plume stack by petrochemical industires.

4. CARBON DIOXIDE SEQUESTRATION PROCESS

A carbon sequestration program is helping to develop technologies to capture, purify, and store carbon dioxide (CO_2) in order to reduce greenhouse gas emissions without adversely influencing energy use or hindering economic growth. Carbon sequestration technologies capture and store CO_2 that would otherwise remain in the atmosphere for long periods of time. Worldwide CO_2 emissions from human activity increased from an insignificant level two centuries ago to more than 33 billion tons today. The US Energy Information Administration predicts that, if no action is taken, the US will emit 8800 million tons of CO_2 by 2030, a 33% increase above 2005 emission levels. Carbon capture and sequestration begins with the separation and capture of CO_2 from power plant flue gas and other stationary CO_2 sources. CO_2 capture is the separation of CO_2 from emission sources or from the atmosphere and the recovery of a concentrated stream of CO_2 that is amenable to sequestration or conversion. The use of chemical absorbents, membranes, hydrates, and other approaches has been found to have some degree of potential in capturing carbon dioxide from a stream of gas. Efforts are focused on systems for capturing CO_2 from coal-fired power plants, although the technologies developed will be applicable to natural-gas-fired power plants, industrial CO_2 sources, and other applications. Aqueous amines are the state-of-the-art technology for CO_2 capture from petrochemical power plants. Other highly-rated chemical for carbon dioxide capture is glycol-based selexol sorbent and other mechanisms for CO_2 molecules are dissolvable, and in brine react with minerals to form solid carbonates, are adsorbed in the pores of the rock. But the degree to which a specific underground formation is amenable to CO_2 storage is difficult to discern. One basic limitation to this process is the presence of other trace impurities in the flue gas tend to reduce the effectiveness of the carbon dioxide absorbing process, coupled with the huge financial implication involved.

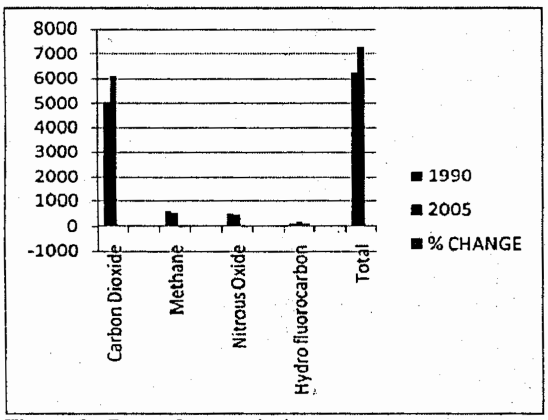


Figure 8: Rate of gas emission

5. ENERGY EFFICIENCY AND INSULATION TECHNOLOGY

This technology applies mostly to the use of energy to heat buildings; specifically for those living in cold regions. The idea behind energy efficiency is simple, if people consume less energy, there will be reduced emission of greenhouse gases. Energy efficiency was important as consumption of non-renewable energy sources posed a serious threat to the environment. Specifically, use of fossil fuels contributed to air and water pollution, sulphur dioxide was produced when oil, coal, and gas combusted in power stations, heating systems, and car engines. Carbon dioxide in the atmosphere acted as a transparent blanket that contributed to the warming of the earth, or the "greenhouse effect." It is possible this warming trend could significantly alter the weather. Possible impacts included a threat to human health, environmental disaster such as rising sea levels damaging coastal areas and major changes in vegetation growth patterns that could cause extinction of plant and animal species. Sulphur dioxide was also emitted when coal was burned. It reacted with water and oxygen in the clouds to form precipitation known as "acid rain." Acid rain kills fish and trees and damages soft stone buildings and statues. The problems can be addressed by efficiently using the energy. Every kilowatts of energy conserved has a way of protecting the environment from further destruction caused by greenhouse gases. Human concepts such as the use of bicycles and the idea of treking short distances are aimed at reducing the level of harmful gases poured into the environment.

An easy and effective energy efficient technology available today, is insulation technology. Here the walls and roof of buildings are insulated with materials such as glass fibre, mineral wool or foam. Insulation enables consumers to conserve more energy, thereby reducing the emission levels.
In Figure 9 it shows the energy savings realised when residential and commercial buildings are insulated. It can be seen from the bar chart how much energy is saved when insulation technology is used. The whole idea is to reduce the degree of gases lost through emissions.

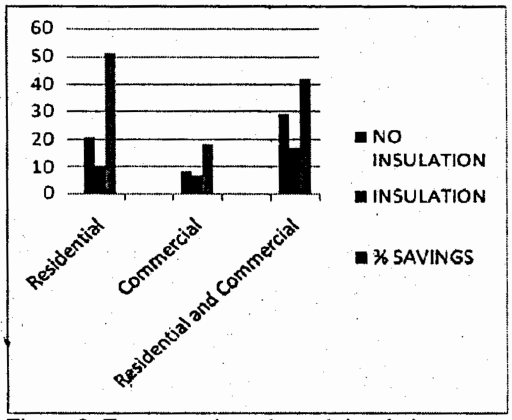


Figure 9: Energy savings through insulation

Sources: ["Green and Competitive Energy, Environment and Economic Benefits of fiber glass and mineral wool insulation products. "by Energy Conservation Management 1996]

6. ENVIRONMENTALLY FRIENDLY ENERGY SOURCES

6.1 BIO - ENERGY

Biogas is used not only for cooking, heating, and lighting in rural households, but also offers ecological benefits. Through anaerobic fermentation, elements of hydrogen and carbon are separated from nitrogen, phosphorus, potassium, boron, molybdenum, zinc, and iron, which are used as fuels and fertilizers. The methane produced in rice fields as a pollutant can be converted into a useful fuel in a biogas digester. Biogas technology, therefore, utilises biomass energy and also provides one of the best environmental protection measures. Other examples of biofuels include biodiesel and bioethanol from fats/oil and grains respectively. These sources of energy are being used in advanced countries and in Brazil, the worlds leading producer of bioethnol. They are capable of not only meeting energy demands, but also carry the advantage of generating little or no harmful emissions.

6.2 SOLAR AND WIND ENERGY

Alternative energy sources (solar and wind,) provide an ability offer a large level of redundancy in sources so that countries are not dependent solely on the natural resources of another nation. This also provides a much cleaner energy and reduces the tremendous pollution problems caused by fossil fuel. The profitability of alternative energy is an investment that begins today and pays off tomorrow. The point of alternative energy is to provide sustainable, clean, cost effective, and localised energy to all communities. Solar energy is relevant today because of its numerous advantages. Some advantages are: solar energy is clean, renewable (unlike gas, oil and coal) and sustainable, helping to protect the environment. It does not pollute the air by releasing carbon dioxide, nitrogen oxide, sulphur dioxide, or mercury into the atmosphere as do traditional forms of electrical generation. Solar energy therefore does not contribute to global warming, acid rain or smog.

6.3 AFRICAN RENEWABLE ENERGY SITUATION

Table 4: Small hydropower developed and potential in selected African countries
Source: Karekezi and Ranja, 1997, Unilever Kenya, 2006.

Country	Small Hydro potentials [MW]	Harnessed [MW]
Uganda	46	8.0
Mauritius	-	6.70
Kenya	600	14.0
Burundi	42	18.0
Zambia	4	1.05
Tanzania	70	9.0
Lesotho	-	8.74

Table 5: Average Wind Speed Potential and Number of Wind Pumps
Sources: Diab, 1988; Stassen, 1986; Linden, 1993; Fraenkel et al., 1993; Kenya Engineering, 1994;

Countries	wind speed potentials (m/s)	Number of wind pumps
Botswana	2 – 3	200
Djibouti	4	7
Nigeria	3.5 – 5.5	-
Eritrea	3.8	<10
Guinea	2.4 – 4.0	-
Kenya	3	272

7. SOME RESULTING EFFECTS OF GAS EMISSION

7.1 OZONE LAYER DESTRUCTION

Studies indicate, ozone layer is being damaged by increasing use of industrial chemicals named chlorofluorocarbon [CfCs], which are used in refrigeration, air conditioning, cleaning solution, packaging materials and aerosol sprays. Chlorine, a chemical by product of [CfCs], attacks ozone, which consists of three molecules of oxygen, by taking one molecule away to form chlorine monoxide. Chlorine monoxide then reacts with oxygen atoms to form oxygen molecules, releasing chlorine molecules that continuously break up the ozone molecules.

The ozone layer is formed from a series of chemical reactions:

1. Photolysis by UV light to form atomic oxygen.
   $O_2 + hv \rightarrow O + O$
2. Recombination reaction in the presence of a third body which is mostly nitrogen, Needed for momentum and energy conservation

$$O_2 + O + M \rightarrow O_3 + M$$

7.1.1 Breakdown Of The Ozone Layer

1. Breakdown of Halogenated compound [CfCs]
   $$CCl_2F_2 \rightarrow C + 2Cl + 2F$$
2. Ozone layer attack by the molecular chlorine to form chlorine monoxide.
   $$O_3 + Cl \rightarrow ClO + O_2$$
3. Recombination of chlorine monoxide forming another chlorine molecule
   $$ClO + ClO \rightarrow 2Cl + O_2$$
4. Attack on the ozone layer by the molecular chlorine forming chlorine monoxide
   $$O_3 + Cl \rightarrow ClO + O_2$$

This reaction occurs millions of times in a second, thus gradually depleting the ozone layer and exposing the whole earth to the effects of short wave thermal radiation from the sun.

7.2 GLOBAL WARMING "ARMAGEDDON OR BURST"

Carbon dioxide is a major by-product of fossil fuel combustion; others include SO_2 and methane from the burning of coal. It is what scientists call a greenhouse gas. Greenhouse gases absorb solar heat radiated from the earth's surface and retain this heat, keeping the earth warm and habitable for living organisms. Rapid industrialisation through the 19th and 20th centuries, however, has resulted in increasing fossil fuel emissions, raising carbon dioxide in the atmosphere by about 28%. This dramatic increase in carbon dioxide has led some scientists to predict a global warming scenario that could cause numerous environmental problems, including disrupted weather patterns and polar ice cap melting. [5]

7.2.1 Consequences

Global warming has led to an increase in the mean earth surface temperature and thus to the melting of polar ice. There are frequent meltdown of glaciers that result in floods and other natural calamities. The melting of ice at the poles had led to an increase in the mean sea level from an increasing mean earth surface temperature. The effect of global warming is also evident on the plant animal kingdom. Some animals have become extinct due to loss of natural habitat or an inability to evolve to the rapid changes in the climate. There is also serious destruction of plant from drastic seasonal change

7.2.2 Remedies

There are two major approaches to slowing the buildup of greenhouse gases. The first is to keep carbon dioxide out of the atmosphere by storing it or its carbon component somewhere else, a strategy known as carbon sequestration. A second major approach is to reduce the production of greenhouse gases. The simplest way to sequester carbon is to preserve trees and to plant more. Trees, especially young and fast-growing saplings, soak up a great deal of carbon dioxide, break it down in photosynthesis, and store the carbon in new wood [6]. Government and international policies banning the use of halogenated compounds as refrigerants also encourage solar energy which is environmentally friendly. Nuclear energy, although controversial for reasons of safety and the high cost of nuclear waste disposal, releases no carbon dioxide. Solar power, wind power, and hydrogen fuel cells also emit no greenhouse gases. Someday these alternative energy sources may prove practical.

7.3 Acid Rain Deposition

$SO_2 + H_2O$ ---------- H_2SO_3

$CO_2 + H_2O$ ---------- H_2CO_3

Acid rain is caused by a combination of sulphur dioxide and nitrogen compound with water in the atmosphere to produce rain with a low pH making it highly acidic. With the addition of sulphur and nitrogen compounds, the pH of rainwater may drop to as low as 2.0 or 3.0 similar to the acidity of vinegar. In addition to chemically burning the leaves of plants, acid rain poisons lake water which kills most if not all aquatic inhabitants.

8. GOVERNMENT'S ROLE IN PROMOTING USE OF BIOFUELS

All governments must see it as a step in the right direction the support and creation of an enabling environment for the continous use of biofuels. Policy makers should attemt to integrate renewable energy usage into countries' energy mix. Other government efforts should include:

- **Awareness creation:** Government should educate the rural poor on the efficiency and environmental benefits of a biogas digester. This form of education must involve practical demonstration.
- **Manpower training:** Local artisans must be trained on the design and construction of a biogas digester, since the construction requires high degree of skills. If possible, government should introduce such technology in to the curricular of secondary and tertiary schools under "renewable energy programme.
- **Participation:** Government should take an active part in biogas projects as in the experience of China, India and Nepal. Non-governmental organisations should be encouraged to take active participation in such technology.

9. CONCLUSION

The key to improving the environment and enhancing sustainable development is the design of technological concepts to help reduce energy usage and associated air emission, while protecting the immediate environment from the danger of accumulations of greenhouse gases. The use of environmentally friendly energy sources, carbon dioxide capturing methods and the overwhelming role of energy efficiency and insulation would help meet the goals of energy savings, gas emission mitigation and sustainable development.

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11. AUTHORS

Principal Author: Mr. Ilaboya Idowu Rudolph holds ND/HND in Polymer Engineering from Federal Polytechnic Auchi Nigeria, Post Graduate Diploma in Chemical Engineering from Federal University of Technology Minna Nigeria. He is a recipient of the Alumni and Rector's merit award of the Federal Polytechnic Auchi. He is undergoing a master's degree programme in Water Resources and Environmental Engineering University of Benin, Benin City. He is a Technologist in the Department of Chemical Engineering, Igbinedion University Okada, Nigeria.

Co-author: Samuel Tita Wara holds the B.Eng, M.Eng, and Ph.D. degrees in Electrical Engineering from the University of Benin, Nigeria. He is a chartered electrical engineer, a fellow of the Nigerian Society of Engineers, a fellow of the Institution of Engineers, Tanzania. At present he is a Professor Electrical and Computer Engineering and Dean of the Gen. Abdusalami A. Abubakar College of Engineering, Igbinedion University, Okada, Nigeria. He is the Director of Product development/Energy centres. He has also served as the Director of academic planning and Acting Vice-Chancellor of Igbinedion University, Okada.

[Author Email Address: id_rudolph@yahoo.com]

Presenter: The paper is presented by Mr. Ilaboya Idowu Rudolph

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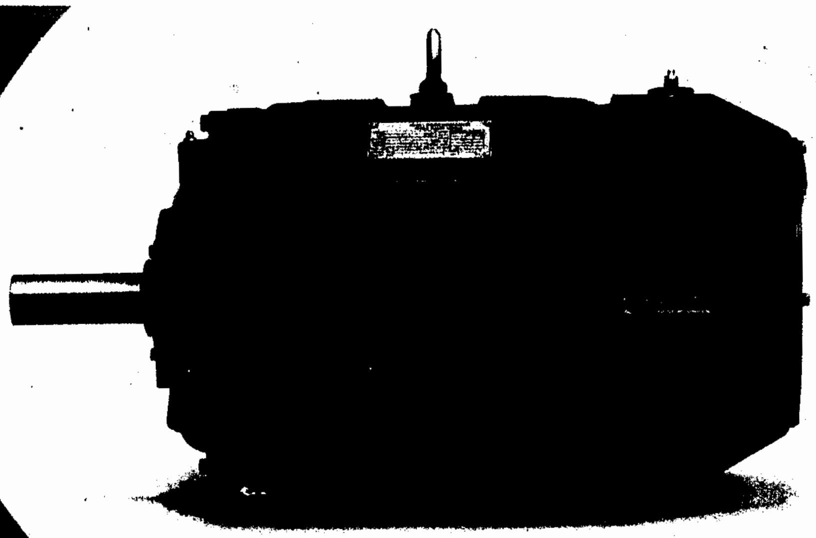

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