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Use of Novel Green Energy Design in Sustainable Buildings to Mitigate Effects of Climate Change

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***Abstract*— Today it is indisputable that human activities have contributed to climate change. In 2007, Intergovernmental Panel on Climate Change (IPCC) produced an evaluation report that estimated an increase in greenhouse gases released by human activities by 70% between 1970 and 2004. Scientific research suggests that climate change impacts adversely on the environment. For instance, the recent rise in severe weather happenings, shortages of water and food, changing patterns of disease, a rise in sea levels and loss of tropical forests can be attributed to climate change. It is estimated that buildings produce a substantial amount of greenhouse gases in their operational phase. Research that has been carried out estimates that buildings produce over 33% of greenhouse gasses into the environment. Therefore, if careful efforts are directed towards reducing greenhouse releases by the building sector, there will be significant reductions in climate change. This study explores the potential of the building sector in reducing greenhouse emissions. It provides an assessment of the climate change, greenhouse emissions and how sustainable buildings will help mitigate the dangers of climate change.**

Keywords*— *Climate change, GHG emissions, Global warming, Green energy, Green energy conservation, Renewable energy, Sustainable buildings, Climate change Mitigation.

I. INTRODUCTION

Climate change is the fluctuations in the climatic behavior of a place or region, through statistical measurements over a period of time, as a result of a variety of factors [1]. There are many natural processes on earth that contribute to climate change. However, direct and indirect human activities have contributed greatly to the change in climate. The contribution of human activities to climate change was also emphasized by the United Nations Convention Framework on Climate Change in 19994 [2]. In the perspective of the environmental policy, climate change might be limited to the anthropogenic impact on the environment or the human impact on global warming. However, this perspective is viewed differently by the National Aeronautics and Space administration (2013) [3]. According to the National Aeronautics and Space administration (2013) [3], global warming is the aggregate rise of temperatures in the atmosphere while climate change broadly incorporates global warming and other environmental changes as a result of increased release of environmental greenhouses. However, it should be noted that global warming causes differed climatic variations in different areas. Therefore, the effects of climate change are specific to a given location on earth. The Department of Ecology in Washington, DC (2012) [4], suggests that climate change will affect livelihoods, different cultures and biodiversity.

Today, the amount of energy used by the buildings in developing and developed countries is about forty percent of the total global consumption. It is estimated that, from this consumption, the building sector produces over 30% of the global greenhouse emissions. In 2004, the IPCC fourth evaluation report approximates that the building sector produces about 8.7 million metric tons eqv [5]. The most disturbing trend is the rate at which greenhouse gas emissions are growing. According to Levine et al [5], it is estimated that the total carbon dioxide GHG emissions from residential buildings at a rate of 1.8% annually while commercial buildings have had an annual increase of 2.5% for the period between 1971 and 2004.

In addition, Montreal Protocol indicated that a substantial amount of non-carbon dioxide GHC is released by the buildings and the construction sectors. These non-carbon dioxide greenhouse gases include halocarbons, chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs) and hydro fluorocarbons (HFCs). These greenhouse gases are mainly used in cooling, refrigeration, and insulation materials. According to Levine et al [5], the IPCC predicts a high rate of increase in GHG emissions from the building sector. It estimates that by the year 2030, GHG emissions from the building sector could be doubled to 15.8 million metric tons of CO2 eqv. The building and construction sector is growing at a huge rate, especially in second world economies. Furthermore, there are a lot of inefficiencies in the current buildings which attributes to the high rate of increase in GHG emissions from the building sector. Therefore, reducing GHG emissions from the building sector must be included in the global strategy in dealing with climate change. The entire mitigation efforts must revolve around green energy and sustainable buildings.

II. STATEMENT OF THE PROBLEM

Generally, this study aims to examine Sustainable/Green building's potential of reducing greenhouse gas (GHG) emissions and mitigating the effects of climate change. Specifically, the concerns of the study are:

1- What is the current status of the Earth under climate change and global warming?
2- What is the potential of sustainable buildings in reducing the effects of climate change?

3- What are the green energy technologies that can be used in sustainable buildings?
4- How do the renewable technologies contribute to a building being sustainable?

III. Hypothesis of the Study

Sustainable/Green buildings have a high potential of decreasing (GHG) emissions and alleviating the impact of climate change.

IV. Significance of the Study

This research paper is significant for it introduces and innovative way of participating in the reduction of the effects of climate change. The research design not limited to commercial establishments only but rather extends its scopes to communities and individual homes. The publishing of the research will disseminate the information regarding this green and innovative initiative, giving opportunity to every individual in contributing in minimizing the climate change effects in a much bigger way than recycling and reducing wastes. Since the program incorporated new methods within the foundational structures and operating manners of the buildings and the homes it handles, it can be assured that the process each establishment performs, from water facilities to ventilation and to waste management, adhere to environmental standards.

V. Scope of the Study

The objective of this research paper is to examine the potential of sustainable building in reducing GHG emissions and climate change mitigation. In light of these variables, the methodology of the paper will only concern itself with the gathering of data from reliable sources such as books, journals, officially published research papers, news articles, and acknowledge organizational reports, both local and foreign.

VI. Review of Related Literature

A. Climate Change

In 2012, the Environmental Protection Agency EPA [6] provided an explanation about climate change. The Agency defined climate change as a significant variation in the characteristics of the current climate over a period of time. The agency further defined climate change as a variation that modifies the natural processes of temperature, rainfall or precipitation, and wind patterns that take place at least a decade. The National Aeronautics and Space Administration (2013) [3] provide an outline of the present alterations that the world has undergone and statistics on climate change. These changes include: the minimum Arctic sea ice has reduced at a rate of 13% per decade, rise in sea level at the rate of 3.20mm annually, increase in carbon dioxide concentrations at the rate of 393 PPM, increase in world temperatures to an average of 1.6 Fahrenheit since 1980 and the decrease in Greenland ice at an alarming 100 billion tons annually.

There exist natural processes on the Earth which causes climate change over a period of time [7]. However, according to Shaney, Benton, & Ferry [8], anthropogenic activities contribute immensely to global warming making them the dominant contributors to climate change in various parts of the Earth. However, there are external and internal forces on the earth which are also responsible for climate change [7].

According to Seiz and Foppa [9], in their report, studying the changes in the size of glaciers over time gives a clear indication of the status of climate change on the earth. In 2005, Dyurgerov and Meier [10] conducted logical measurements on glaciers to determine the effects of climate change. In their study, they discovered that the glacier's cumulative thickness change has been on a steady decline since the 1960s.

Another indicator which can be used to assess the impact of climate change as proposed by the National Aeronautics and Space Administration (2013) [11] is assessing the ice loss in the arctic sea. According to the statistics carried out at the National Snow and Ice Data Center (2013) [11] specifies that between the years 1979 and 2000, the rate at which the Arctic Sea ice is decreasing has reached a rate of 11.6% per decade. Scientists usually use precipitation as the indicator to evaluate the status of climate change, with the past trends in precipitation obtained though ice cores, sediments in marine systems and even tree rings [12]. It is clearly evident that climate change affects precipitation. According to scientific research, low precipitation polar deserts used on Earth 18,000 years ago [13]. Consequently, in the same study, the authors affirm that the rate of precipitation on the earth today is higher compared to 8,000 years ago.

Another indication of the effects of climate change is the trends in vegetation cover on the surface of the earth. This effect can be demonstrated by the collapse of Carboniferous Rainforests 305 million years ago due to climate change which led to the extinction of thousands of vegetation species [14]. The current rate at which climate change is taking place could lead to widespread desertification especially in areas where animals have reached the heat tolerance limit [15].

B. Sustainable Buildings/Green Buildings/Green Construction

A sustainable building is an architectural structure that uses an environmentally materials and uses self-sustaining energy resources during the lifetime of the building. The process of making a building sustainable begins from the design stage, followed by construction, then operation and maintenance, and lastly during renovation and demolition. This process is not an individual effort, but requires collaboration of designers, architects, engineers and the client at all phases of the project. Traditional structures had design problems from cost, effectiveness, resiliency and comfort. Sustainable buildings solve these problems by utilizing an architectural design that efficiently uses water and energy materials and built using materials that are environmentally friendly.

There are many direct and indirect adverse effects on the environment that result from construction and operation of buildings. During the operation of the building energy, water and other raw materials must be utilized to sustain the life of the occupants and the building. Furthermore, there are various wastes that are generated from the occupants of the

building and during construction and demolition. Also, buildings release various GHG gases during its life cycle from the various forms of energy that contribute to global warming and climate change. Therefore, the stakeholders of the building industry, including architects, designers, and building owners are faced with distinctive challenges meet the demands for novel and renovated structures. They are trying as much as possible to make the buildings manageable, safe, and productive while reducing their effects on the environment.

Architects and designers have struggled to make buildings sustainable in novel and innovative ways and some of them have successfully constructed structures that solve the environmental impacts. They have tried to solve challenges involving water usage, consumption of energy in heating, cooling and refrigeration, and the way wastes are managed in buildings among others. Green buildings are found in various regions of the world with different climates and functions. The green buildings can be homes, offices, courthouses, hotels and restaurants among others and this shows how adaptable and flexible green buildings are.

There are various ways in which buildings can be made sustainable. In the current world, there are many economic problems and building new buildings is relatively expensive. Therefore, the most economical way to start with is to make major design decisions that will make buildings sustainable in order to reduce operational costs and impacts on the environment, and this can also improve the resilience of the building.

The ways in which sustainable building design is perceived by various stakeholders in the building industry is regularly changing. However, there are six basic principles that are constant.

1. Optimization of the site potential: In order to create sustainable buildings, the first thing is to properly select the site. This might include renovation of the current buildings. Since it is clear that affect the environment and energy use, the location, landscaping of a building should be appropriately selected. The site design must combine with sustainable design in order to attain effective results, whether it is building a fresh building or renovating the current building. The site chosen for a sustainable building should lessen, regulate, and /or treat storm water runoff.

2. Energy uses optimization: Designers and architects of the building should design energy sustainable buildings. In addition, existing buildings should be renovated to increase their energy efficiency and increase energy independency. All the people concerned in the government sector, including the government and private sectors, should commit themselves to build and operate net zero energy buildings as a substantial mechanism to reduce energy derived from the fossil fuels.

3. Protect and Conserve Water: A sustainable should have the ability to reuse water resources in an efficient manner. Since water resources are increasingly becoming scarce every day, water should be recycled for on-site use whenever possible.

4. Using Greener Materials: Greener materials are capable of minimizing environmental impacts during the operation of the building and during demolition. The environmental impacts include global warming, depletion of resources and toxic substances to the occupants. Materials that are environmentally friendly will be able to improve the well-being and working environment of the occupants, and the environmental safety.

5. Develop Indoor Environmental Quality (IEQ): The internal conditions of the building should have a direct impact on the overall safety, health comfort and productivity. These conditions should allow maximum daylight harvesting, and should have proper ventilation. Furthermore, the occupants of the building should be able to have full control over lighting, temperature and other systems.

6. Operational and Maintenance Optimization: The design phase of a building is important in incorporating optimal operation and maintenance measures. If the building is designed properly, there will be less system failures, minimized energy costs, improved working environment and higher productivity. During the design phase, it is crucial for designers to include materials that are simple and require less maintenance.

C. Renewable/Green Energy Technologies in Sustainable Buildings

1) Electronic glass technology

Research engineers are on the process of perfecting the glass of superior quality. It is called the electronic glass or e-glass. This is a perfectly transparent material that adapts to changing light and heat by altering transparency to regulate energy flow [16]. Typically, during summer smoldering sun blasts through the window to resuscitating the air-conditioning to keep the interior cool. During winter, buildings produce heat. But if the glass can be adapted to changing weather condition buildings could save millions and be more comfortable. An electronic glass consists of film placed inside the center of the glass. When electric current is passed through the glass, the particles in the film allow light to pass through and the glass becomes transparent [16]. When there is no current, the glass is dark and no light will pass through and at the same time the harmful ultraviolet rays from the sun are blocked [5]. Also, to stimulate the transparency of the glass, only a pulse of electricity is required. Therefore, sustainable buildings with electronic glass would save billions in cooling costs.

The buildings might adjust immediately to varying light situations regulating the climate inside. The e-glass could further add energy savings by reducing dependency on electric lights thanks to the process of daylight harvesting. Daylight harvesting is when the building uses day lighting instead of interior lighting [17]. Instead of spending energy with the interior lighting, the building can use glass to bring illumination into the building without using energy. With e-glass regulating the temperature inside, the amount of energy required to heat and air-condition the building would drop as much as half [17].

2) Fuel Cells and Renewable Hydrogen

A fuel cell is electrochemical equipment that uses oxygen and hydrogen gases to generate electricity [18]. A fuel cell device operates like a battery, but it does not run down as long as the supply of the two gases is constant. Fuel cells can

be used to generate the desired amount of electricity by stacking together individual fuel cells. The fuel cell is environmentally friendly since it produces water and a little heat as the only by products and they are efficient (up to 87%) as compared to conventional combustion technologies which have efficiency of about 34% [19]. The fuel cells can be used to provide electricity to a wide range of applications. In sustainable buildings, fuel cells can be used to supply electricity to a wide range of applications such as computers, cooking and in refrigerators among other many applications.

The only two raw materials for the production of electricity from the fuel cell are oxygen and hydrogen gases. Hydrogen gas is abundantly available from domestic resources such as natural gas, and biomass among other sources. Solar and wind renewable technologies can produce hydrogen gas through the process of water electrolysis [18]. Water electrolysis is the process of generating hydrogen and oxygen from water using electricity. The cogeneration home fuel cell can tap hydrogen gas from the natural gas line at home. The home fuel cells can produce 500 watts up to 1 megawatts of electricity and the heat produced from the system can be used for heating purposes like warming tank water for showering, or washing dishes and so on. This form of renewable energy can make building sustainable and energy efficient [18].

3) Solar Power/Photovoltaic

Solar photovoltaic (PV) is a technology that uses solar power to produce electricity. This technology uses semiconductor material to change solar radiation directly into electricity [17]. The technology requires minimal maintenance since the photovoltaic cells are arranged in arrays and have no moving parts [20]. The photovoltaic projects can be used to provide electric power for the whole building. The photovoltaic solar panels are placed at a point where there is sufficient sunlight especially at the rooftops. The photovoltaic cells produce clean energy [20]. Therefore, they can make a building energy sufficient and therefore sustainable and mitigate the effects of climate change.

Despite the contribution it does regarding mitigating the effects of climate change, there are still some environmental issues that need to be tackled when it comes to the consumption of solar energy. Although solar power does not bring any harmful environmental effects when operated [21], the process of its production, however, does [1]. The use of cadmium in PV films is one of the issues being raised, since this element frequently deposits in many ecosystem food chains [22].

4) Wind Power

Much of wind power is used to convert wind energy into readily available advantages such as running turbines to produce electricity [23], windmills of mechanical works [24] and wind pumps for drainage, propelling as for ships, and water pumping [25].

The use of wind power displays a promising growth trend, since in 2010, almost half of the global wind power installations occurred outside from the traditional market of Europe and North America [26]. The wind energy sector was affected by the recent global crisis. However, starting 2008, its growth averaged to 27.6% each year and was projected to increase to 15.7% by 2013 [27].

Similar to solar power which only depends on the solar energy, wind energy resource is also highly dependent on wind, which has a very variable speed [28]. However, wind forecasts are available in large areas, making wind as a predictable energy source [29].

Unlike fossil fuels and other traditional energy sources, wind power has minimal effects on the environment, considering that it does not necessitate the consumption of fuel and does not contribute to air pollution as well. The probable main disadvantage of wind power is the large requirement for land space. However, agricultural sites can be considered [30]. The mortality of birds and bats are also addressed around the turbines [31], but the effect of this occurrence is unpredictable as far as ecosystems are concerned [32].

There is a high public acceptance of wind power across Europe, as shown by the public polls given out by private sectors [33]. A study shows that 80% of Europeans are in favor of wind power utilization [34].

VII. METHODOLOGY: ELECTRONIC SEARCHING OF THE DATABASE

A. Data Gathering

Much of the data collected in this research were done through searching of the various databases for information related to global warming, climate change and sustainable buildings. Much of the data were obtained from the Environmental Protection Agency (EPA), Environmental Impact Assessment (EIA) website and the Intergovernmental Panel on Climate Change (IPCC). The above agencies provided the data on the amount of carbon dioxide emissions by the residential and commercial sector in the United States. The above research study was to investigate the potential of the building sector in reducing the greenhouse gas and alleviate the impact of climate change. The investigation was carried out in the United States building sector comprising of the residential sector and the commercial building sector. The building sector was investigated for metric tons of carbon dioxide released by the residential and commercial sectors. The empirical and quantitative data from the sources were analyzed to produce various results.

TABLE I. US CARBON DIOXIDE EMISSION FROM RESIDENTIAL SECTOR, 1990-2008. SOURCE: EIA – 2008 RETRIEVED FROM HTTP://WWW.EIA.GOV/ENVIRONMENT/EMISSIONS/GHG_REPORT/

Table 7. U.S. Carbon Dioxide Emissions from Residential Sector Energy Consumption, 1990-2008
(Million Metric Tons of Carbon Dioxide)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petroleum																			
LPG	23.0	24.6	24.1	25.1	24.9	25.5	29.8	29.1	27.3	33.7	35.6	33.8	34.2	35.6	33.5	32.6	28.7	30.4	28.6
Distillate Fuel	71.6	68.1	71.7	71.2	70.2	66.2	67.7	64.0	56.5	60.6	66.2	66.4	62.9	66.2	67.6	62.5	52.1	53.1	50.1
Kerosene	4.6	5.2	4.7	5.5	4.7	5.4	6.4	6.7	7.8	8.0	6.8	6.9	4.3	5.1	6.1	6.1	4.8	3.2	1.4
Petroleum Subtotal	99.2	97.9	100.5	101.8	99.8	97.1	104.0	99.7	91.6	102.3	108.6	107.1	101.5	106.8	107.2	101.1	85.5	86.7	80.1
Coal	3.0	2.4	2.5	2.5	2.0	1.7	1.6	1.5	1.1	1.3	1.1	1.1	1.2	1.2	1.1	0.8	0.6	0.7	0.7
Natural Gas	238.3	247.6	254.9	268.6	263.2	262.9	284.1	270.2	246.5	256.5	270.8	259.4	266.1	277.5	264.5	262.7	237.5	256.8	265.0
Electricity[a]	618.2	625.9	618.1	663.1	664.2	673.9	705.2	714.7	754.1	756.6	799.3	799.7	828.9	839.5	849.1	889.9	863.0	890.9	874.4
Total	958.6	974.8	976.0	1,036.0	1,029.2	1,035.5	1,094.9	1,086.2	1,093.4	1,116.7	1,179.8	1,167.3	1,197.6	1,224.9	1,221.9	1,254.5	1,186.7	1,235.1	1,220.1

[a]Share of total electric power sector carbon dioxide emissions weighted by sales to the residential sector.
Notes: Data in this table are revised from the data contained in the previous EIA report, Emissions of Greenhouse Gases in the United States 2007,
DOE/EIA-0573(2006) (Washington, DC, December 2008). Totals may not equal sum of components due to independent rounding.
Source: EIA

TABLE II. US CARBON DIOXIDE EMISSION FROM RESIDENTIAL SECTOR, 1990-2008. SOURCE: EIA – 2008 RETRIEVED FROM HTTP://WWW.EIA.GOV/ENVIRONMENT/EMISSIONS/GHG_REPORT/

Table 8. U.S. Carbon Dioxide Emissions from Commercial Sector Energy Consumption, 1990-2008
(Million Metric Tons of Carbon Dioxide)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petroleum																			
Motor Gasoline	7.9	6.1	5.7	2.1	1.8	1.3	1.9	3.0	2.7	2.0	3.1	2.6	3.2	4.2	3.4	3.2	3.4	4.2	4.0
LPG	4.1	4.3	4.3	4.4	4.4	4.5	5.3	5.1	4.8	5.9	6.3	6.0	6.0	6.3	5.9	5.8	5.1	5.4	5.0
Distillate Fuel	39.2	37.8	37.1	36.1	36.6	35.0	35.3	32.5	31.4	32.1	35.9	37.2	32.5	35.2	34.4	32.7	29.4	28.1	26.5
Residual Fuel	18.1	16.7	14.9	13.6	13.5	11.1	10.8	8.8	6.7	5.8	7.2	5.5	6.3	8.8	9.7	9.1	5.9	5.9	5.6
Kerosene	0.9	0.9	0.8	1.0	1.4	1.6	1.5	1.8	2.3	1.9	2.1	2.3	1.2	1.3	1.5	1.6	1.1	0.7	0.3
Petroleum Subtotal[a]	70.1	65.8	62.7	57.2	57.8	53.6	54.8	51.2	47.9	47.7	54.7	53.6	49.2	55.8	54.9	52.4	44.8	44.3	41.4
Coal	11.8	11.0	11.2	11.2	11.2	11.1	11.6	12.3	8.9	9.8	8.8	9.2	8.6	7.8	9.8	9.2	6.2	6.7	6.4
Natural Gas	142.3	143.3	182.3	155.1	157.2	164.3	171.2	174.3	163.6	165.3	172.5	164.3	171.1	173.7	170.0	163.2	154.0	164.2	169.9
Electricity[a]	560.8	561.2	561.4	588.7	601.4	616.1	638.5	682.0	719.3	729.4	777.2	792.3	788.2	788.7	808.6	834.8	830.0	855.2	857.3
Total	785.1	786.3	787.6	813.2	827.6	845.1	876.0	919.8	939.7	952.2	1013.1	1019.5	1018.0	1026.1	1043.3	1059.6	1034.9	1070.3	1075.1

[a]Includes small amounts of petroleum coke.
[b]Share of total electric power sector carbon dioxide emissions weighted by sales to the commercial sector.
Notes: Data in this table are revised from the data contained in the previous EIA report, Emissions of Greenhouse Gases in the United States 2007,
DOE/EIA-0573(2006) (Washington, DC, December 2008). Totals may not equal sum of components due to independent rounding.
Source: EIA

TABLE III. DISTRIBUTION OF TOTAL U.S. GHG EMISSIONS BY END-USE SECTOR, 2009 (MILLION METRIC TONS CARBON DIOXIDE EQUIVALENT) SOURCE: EIA – 2009 RETRIEVED FROM HTTP://WWW.EIA.GOV/ENVIRONMENT/EMISSIONS/GHG_REPORT/

Sector	Residential	Commercial	Industrial	Transportation	Electric power
Total greenhouse gas emissions per sector	1,186.20	1,288.30	2,239.90	1,861.20	2,160.30

VIII. DATA ANALYSIS

Data in the above tables is analyzed in the diagrams below to illustrate the trends in carbon emissions from the residential and commercial sectors. The data are also analyzed to indicate the percentage contribution of residential and commercial sectors to the total GHG emissions.

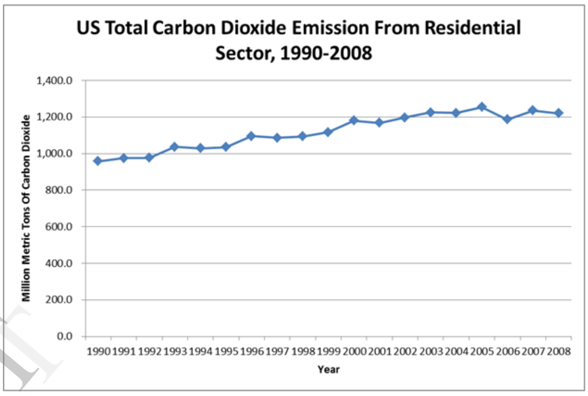

Fig. 1. US Total Carbon Dioxide Emission from Residential Sector, 1990-2008

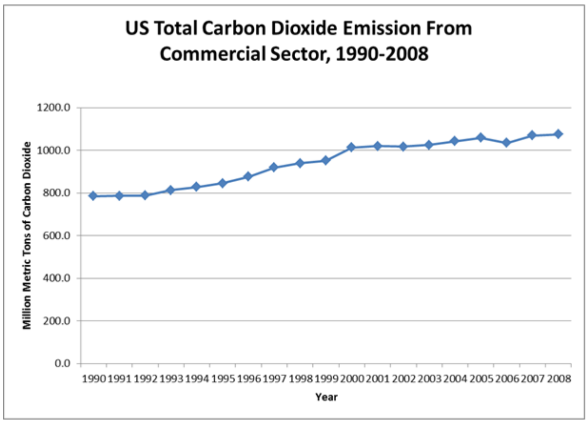

Fig. 2. US Total Carbon Dioxide Emission from Commercial Sector. 1990-2008

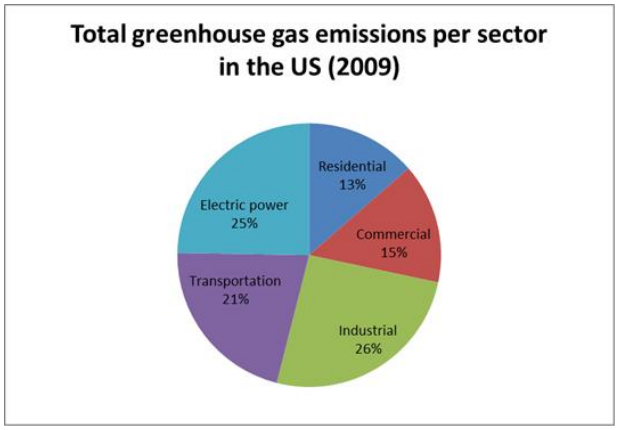

Fig. 3. Total greenhouse gas emissions per sector in the US (2009)

IX. Results and Discussion

The above research study was to investigate the potential of the building sector in reducing the greenhouse gas and mitigate the effects of climate change. The investigation was carried out in the United States building sector comprising of the residential sector and the commercial building sector. The building sector was investigated for metric tons of carbon dioxide released by the residential and commercial sectors.

A. Residential Sector

The residential sector usually releases carbon dioxide from: Use of fuel such as natural gas for cooking and heating, and electricity used for heating, cooling, lighting and electronic equipment. The results above show that the annual energy variations are mainly caused the amount of energy consumed during heating in homes and business.

The results further show an upward trend in the amount of carbon dioxide released from 1990 to 2008. This can be attributed to the increase in population, income growth and other factors which increase the number of residential units. From 1990 to 2008, there was an increase in the emissions from the residential sector at an average rate of 1.4% per year. Research conducted from other studies indicate that the population of the US grew at an average rate of 1.14% per year, while per capita income increased at an average rate of 1.72% per year

Generally, there has been an increase in the efficiency of many home appliances and this has greatly offset the increase in the number of residential units. The above results above show that the emissions from consumption of coal, natural gas and petroleum in the residential sector was only 1.53% higher in 2008 than 1990.

B. Commercial Sector

The commercial sector includes structures such as schools, hospitals, hotels and restaurants, and office buildings among others. The carbon dioxide emissions in the commercial sector are as a result of energy consumption for lighting, heating and cooling the commercial structures. As shown from Figure 2, there was an upward trend in the carbon dioxide gas emissions in the commercial sector in 2008.

In the commercial sector, the greatest amount of energy consumption is used for lighting. Looking at the 2007 alone lighting contributed about 18% of the total demand. This is higher compared to the residential sector where lighting only contributed an estimated 11% of the total demand on the same year.

The results also indicate that the residential sector greenhouse emissions are affected more by variations in weather than the commercial sector. For instance, in the year 2007, the residential sector recorded 39% energy demand from heating and cooling alone while the commercial sector only recorded 22%.

Generally, the commercial sector showed an upward trend in the amount of carbon dioxide emissions. This can be attributed to the increase in the economic trends. From 1990 to 2008, the commercial sector emissions increased at a rate of 1.82% per year, which is higher than the per capita income.

The commercial sector recorded a high rate of increase in emissions related to electricity at an average rate of 2.44% annually, while the emissions from fuel consumption showed a decline from 1990 to 2008 in the commercial sector. This result suggests that green buildings in the commercial sector should use electricity forms that do not produce greenhouse gases in order to mitigate the effects of climate change.

X. Findings

1. The study has revealed how climate change causes adverse effects on the environment. The effects are pronounced in certain areas evidenced by retreat of ice caps, desertification, and rise in sea level among others.

2. The study has shown that residential and commercial buildings release more than 30% of the total GHG emissions. The findings also indicate an upward trend in the GHG emissions and it is projected that it may double by the year 2020. This makes the building sector as a potential target in reducing GHG emissions.

3. The study has explored innovative green energy technologies that can be used in building design to reduce GHG emissions. They include wind energy, solar energy, fuel cell technology and electronic glass.

4. The study has shown how the green technologies will make buildings sustainable. Buildings will be energy efficient and sufficient through the use of green energy technologies. The technologies are environmentally friendly and will greatly reduce GHG emissions from buildings.

XI. Conclusion

The residential and commercial buildings have a potential of reducing greenhouse gas (GHG) emissions if the right measures are put in place. Governments, architects, designers and owners should strive to make buildings sustainable in novel and innovative ways to successfully solve the environmental impacts. They should try to solve challenges involving water usage, consumption of energy in heating, cooling and refrigeration, and the way wastes are managed in buildings among others. Green buildings are found in different parts of the world with different climates and functions. The green buildings can be homes, offices, courthouses, hotels and restaurants among others and this

shows how adaptable and flexible green buildings are. The green energy technologies will make buildings energy efficient and will be able to supply their own electrical needs. Furthermore, the amount of GHG emissions will greatly reduce and consequently reduce the threat of climate change. Thus, the innovative green technologies in the building design will make buildings sustainable, reduce the GHG emissions which cause global warming, and help in mitigating the effects of climate change.

XII. RECOMMENDATIONS

Governments should target the building sector in the effort to reduce GHG emissions and reduce the effects of climate change. Currently, there is no legislation involving sustainable development agencies for building sector.

There should be a common effort which is integrated and coordinated in order to collect data which will reveal the energy characteristics of buildings.

Governments should encourage and support "Green Building" strategies. For instance, governments can use "Green Building" certification systems to encourage development of sustainable buildings.

There should be in place surveys and detailed audits which takes into consideration the building types and climatic regions in order to identify the suitable energy technologies for particular applications.

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