



## Energy, Environment and Sustainable Development: A Review

Garba N. and Adamu A.

Department of Environmental and Resources Management, Usmanu Danfodiyo University, Sokoto

### ABSTRACT

The emission of carbon dioxide and other relevant greenhouse gases has led to global warming with unpredictable but potentially catastrophic consequences. When fossil fuels are burnt they emit toxic pollutants that damage the environment and human health. Recent development in renewable energy technologies could help reduce the price of energy and related environmental concerns. Hydrogen could be used as fuel cells and sun for PV panels which are generally considered cheaper and more viable to the environment. There is a strong relationship between energy, environment and sustainable development. As such, these three cannot be separated from one another. Our environment needs to be protected from the effects of burning fossil fuels that result in the release of greenhouse gases such as NO<sub>x</sub>, SO<sub>x</sub> and CO<sub>2</sub> which all of them could lead to global warming. Some of the areas with major concerns include acid rain, stratospheric ozone depletion, global climate change (greenhouse effect), water pollution, radiation and radioactivity, hazardous air pollutants etc. Therefore, achieving SDG-7 which deals with the attainment of the global quest for universal access to affordable, reliable, sustainable, and modern energy by 2030 cannot be possible unless significant effort is made. These include several solutions to the global energy and environmental problems which include; a breakthrough in renewable technologies, energy conservation, energy storage technologies, recycling and energy source different from fossil fuels.

Keywords: Energy, Environment, Sustainability.

### INTRODUCTION

As a result of globalization and civilization, people tend to use energy extensively. People burned wood to have sufficient temperature to melt metals, chemicals extraction, as well as convert the heat into mechanical power, heat for cooking and heating systems (Dincer and Rosen, 1999). During the burning process, the carbon present in wood will combine with the oxygen (O<sub>2</sub>) to form carbon dioxide (CO<sub>2</sub>); the carbon dioxide is then absorbed by the plants and later converted back to carbon for use as fuel again, an example of such is oil, coal and natural gas (Hammond, 2000).

Some drivers that triggered some nations to push for the attainment of sustainable energy development are energy security, economic growth and development, environmental protection and sustainable development. As the world population is increasing and the average increase per annum is more than 2% (Darmawi *et al.*, 2013). Rapid growth in population causes greater energy demand. The rate of consumption is extremely high which is estimated to be around 22 billion kWh a year (Omer, 2008). About 6.6 billion metric tons of carbon equivalent of greenhouse gases (GHG) are emitted to the atmosphere to meet the energy mandate of the world. Approximately, 80% of the

greenhouse gases emitted is due to combustion fuels (Omer, 2008).

Energy sources of various kinds, for instance, heat, power and electricity, these influences human development throughout the world. Although, they put us at risk in terms of quality and longer-term viability (Hammond, 2000). Some several names and terms are used nowadays to describe sustainable development "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Dincer, 2000).

The environment is a major concern of any nation or country. Nowadays, a clean environment is needed where there is no pollution or emissions of harmful gases to the atmosphere. Emissions of gases like CO<sub>2</sub>, NO<sub>x</sub>, and SO<sub>x</sub> causes climate change and change in atmospheric pressure. Carbon dioxide (CO<sub>2</sub>), in particular, is part of greenhouse gases that causes global warming (Darmawi *et al.*, 2013). However, emissions of greenhouse gases could result in environmental pollution and degradation. The nature of the problem stresses a more comprehensive energy policy response that could influence the actions of energy consumers and producers (Turner, 1999).

### SUSTAINABLE RENEWABLE ENERGY FUTURE

The prospects of renewable energy sources that will help in meeting the energy need, countries like the United States, United Kingdom, Brazil, Norway and Germany are a good example to emulate. At predominant economic practice, the alarming degree of global warming would be attained long before the known fossil fuel reserves are gone (Ulrich and Karl, 2010). The future of the world energy economy would be diverse on different sources, but one major concern is the expensive nature of renewable energy technologies especially in operational, construction,

maintenance and payback. Renewable energy is less expensive than conventional combustible energy from natural gas and coal (Abam *et al.*, 2014).

Renewable energy has contributed greatly by reducing the greenhouse gases effect. These renewable energies include; geothermal, solar, hydropower, wind etc. Renewable energy is applied to energy derived from our environment for human use (Ulrich and Karl, 2010). This energy is sometimes called non-conventional energy and is meant to replace conventional energy derived from fossil fuels, coal, oil and natural gas due to two reasons: if we are to continue

\*Corresponding author. E-mail: nura.garba@udusok.edu.ng

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International license

burning them, the reserves will be exhausted before long. The emission of carbon dioxide (CO<sub>2</sub>) is changing our

climate because is part of greenhouse gases (Ajayi, 2013)

### ENERGY SECURITY, ECONOMIC GROWTH AND ENVIRONMENT

As the world population is increasing, the demand for energy security, energy efficiency, and environmental

protection are the major concerns and drivers for the national policy on energy (Omer, 2008).

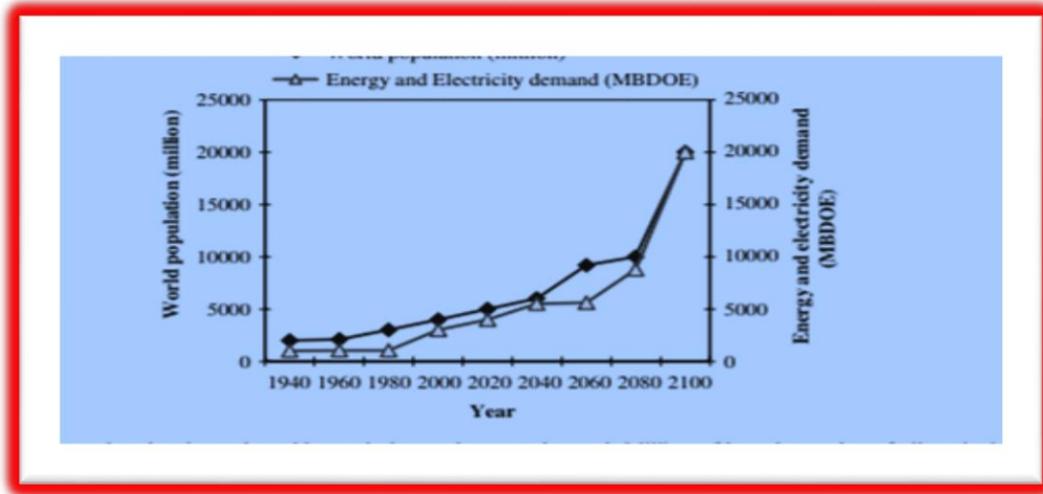


Figure 1: Annual and estimated world population and energy demand (Omer, 2008)

Figure 1 shows the annual and estimated world population and energy demand and the population is increasing, the demand is also increasing simultaneously. The enhancement in lifestyle and energy demand goes in hand with industrialized economics, which contains 25% of the world's population, consume 75% of the world's energy supply. The world energy consumption today is estimated to be more than 22 billion kWh/y (Omer, 2008).

Technological development has changed the world in many ways. It has some negative impacts which include; environmental problems which threaten human health and other wildlife species. The emission of carbon dioxide and other relevant greenhouse gases such as SO<sub>2</sub>, CO<sub>2</sub> and NO<sub>x</sub> has led to global warming with unpredictable but potentially catastrophic consequences (Thai-Ha and Nguyen, 2019). When fossil fuels are burnt they emit toxic pollutants that damage the environment and affect human health with over 700, 000 death recorded each year according to the World Bank review 2000 (Omer, 2008).

Recent development in renewable energy technologies could help reduce the price of energy and related environmental concerns. Hydrogen could be used for fuel cells and sun for PV which is generally considered cheaper and more viable to the environment (Shaaban and Pentinrin, 2014).

The use of solar energy or PV system for everyday electricity has a positive impact: it helps reduce the consumption of resources that are not renewables which are also a threat to the environment through harmful gases emissions, oil spills and toxic by-products (Shaaban and Pentinrin, 2014).

### ENVIRONMENTAL PROBLEMS

Environmental problems have grown dramatically with a wide range of pollutants and hazards that causes degradation to the ecosystem (Dincer, 2000). Some of the areas with major concerns include acid rain, stratospheric ozone depletion, global climate change (greenhouse effect), water pollution, radiation and radioactivity, hazardous air pollutants etc. (Abam *et al.*, 2014).

### ACID PRECIPITATION

Acid precipitation is another form of pollution that affect the environment significantly. In this case, the pollution is produced by the combustion of fossil fuels, specifically from both stationary and mobile sources such as smelters from non-ferrous ores, industrial boilers, and vehicles, are transported over great distances through the atmosphere and deposited via precipitation on the earth on ecosystems that are extremely vulnerable to damage from too much acidity (Sivaramanan, 2015). Some indicators show the damage caused by acid precipitation: acidification of lakes, toxicity to plants from excessive acid concentration, damage to forest and crops, deterioration of materials e.g. buildings, metals and fabrics, and influence of Sulphate aerosols on physical and optical properties of clouds (Dincer, 2000).

Figure 2: Schematic presentation of acid precipitation (Source: Dincer, 2000).

Figure 2 shows a diagrammatic illustration of acid precipitation. The combustion of fossil fuels from boilers, non-ferrous ores and vehicles produced greenhouse gases such as NO<sub>x</sub> and SO<sub>x</sub> which reacted with water through

photochemical reactions to produce acids like H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub>.

The result of electric power generation, heating from residential and industrial areas account for 80% of SO<sub>2</sub> emissions, with coal use alone accounting for 70% of SO<sub>2</sub> emissions. Most of the remaining NO<sub>x</sub> emissions are from the combustion of fuel from stationary sources, volatile organic solvent (VOCs) are released to the atmosphere from different chemicals and compounds (Dincer, 2000).

**STRATOSPHERIC OZONE DEPLETION**

It is a general fact that ozone is present in the lower region of the stratosphere, approximately between altitudes of 12 and 50km, and plays a natural, equilibrium-maintaining role such as absorption of ultraviolet (UV) radiation and absorption of infrared radiation (Svasakthivel and Kumar Reddy, 2011).

Some activities from energy and non-energy are to some extent directly or indirectly responsible for the emissions of harmful gases which has led to stratospheric depletion of the ozone layer (Svasakthivel and Kumar Reddy, 2011).

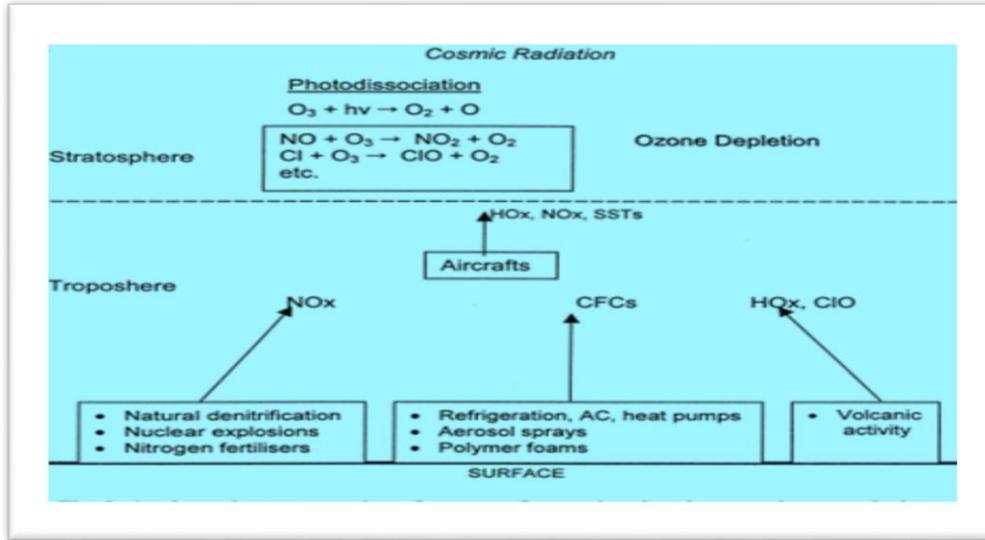


Figure 3: Schematic presentation of ozone depletion (Source: Dincer, 2000).

Figure 3 shows how the depletion of the ozone layer occurs. At the stratosphere layer where the ozone layer gets destroyed as a result of nitrogen oxide (NO) reaction with ozone (O<sub>3</sub>) to produce nitrogen dioxide (NO<sub>2</sub>) and oxygen gas (O<sub>2</sub>). The NO<sub>x</sub> is from denitrification, nuclear explosions and fertilizers. There are also chlorofluorocarbons (CFCs) at the troposphere layer which are from aerosol sprays, polymer foams and refrigeration. Chlorofluorocarbon (CFC) is among the chemicals that cause the depletion of the ozone layer. Recently, in the UK, most production that involves the use of chlorofluorocarbon (CFC) must be reduced as one highlighted in 1999 conference held in London. Though,

there are new technologies that have been developed to help reduce the impact of CFC in most European countries (Dincer and Rosen, 1999).

**GLOBAL CLIMATE CHANGE (GREENHOUSE EFFECT)**

Potentially the most environmental concern comes from energy utilization which causes the greenhouse effect known as global warming. These gases include; SO<sub>x</sub>, CO<sub>x</sub>, NO<sub>x</sub> and CFC. Accumulative atmospheric concentrations of greenhouse gases cause how these gases trap heat radiation from the earth surface thereby increasing the surface temperature of the earth (Global Climate, 2020).

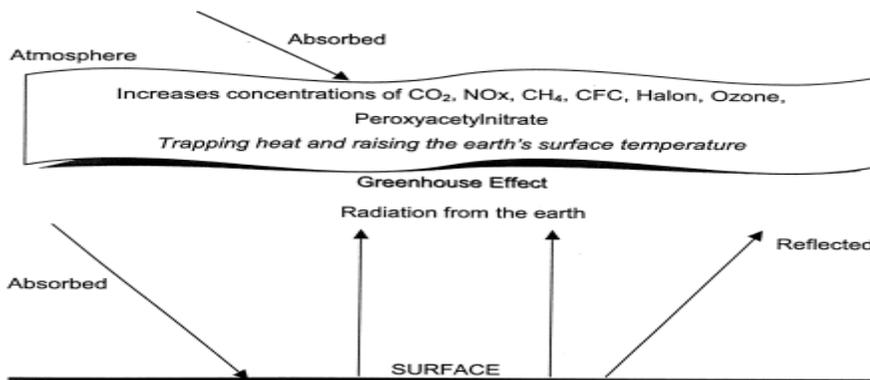


Figure 4: Schematic presentation of the greenhouse effect (Global Climate, 2020).

Figure 4 shows the schematic presentation of greenhouse gases effects. An increase in the concentration of CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, and CFC causes a greenhouse effect also known as global warming.

### POTENTIAL SOLUTIONS TO THE ENVIRONMENTAL PROBLEMS

Renewable energy technologies  
 Energy conservation (efficient energy utilization)  
 Energy storage technologies  
 Energy source different from fossil fuels  
 Policy integration  
 Recycling  
 Carbon or fuel taxes (Dincer and Rosen, 1999).

### RENEWABLE ENERGY TECHNOLOGIES

The use of renewable energy complies with the World Summit on Sustainable Development resolutions organized in Johannesburg, South Africa in 2002 where over 30 countries stated their responsibilities in enhancing renewable energy source use and in setting up their energy synopsis in achieving this aim

### SOLAR PANELS

One of the amazing features of solar panels they do not depend only on the daylight sun but also works on cloudy days. By generating your electricity one could save money from your energy bills. With Government Feed-in tariffs, one could be paid for the electricity generated for each kilowatt-hour (kWh) (Shaaban and Pentinrin, 2014).

The benefits of using solar panels are numerous. It helps by saving energy bills since you do not need to buy electricity from the suppliers. It also helps earn money from generating your electricity and also there is the warranty of ten (10) years for performance.

The solar panels consist of inverters and generating meters for reading the performance and outcome of the panels. When solar radiation reaches and hits the silicon cells in the solar panels, the energy created is electrical energy. The current issue is using cadmium which is known to be a toxic chemical, but to overcome it; magnesium chloride is added to cadmium chloride which is salt found in seawater (Okoye *et al.*, 2016).

### HYDROPOWER SYSTEM

A hydropower system is a possibility by taking part in providing electricity from a clean renewable energy source. In 2005, around 2950TWh of electric energy has been generated from hydropower which is equivalent to 90% of renewable energy and 16% of worldwide energy (Darmawi *et al.*, 2013). In some countries of the world, hydropower plays a significant role in providing electricity. For instance, in Canada (60%), Brazil (84%), Switzerland (55%), Iceland (80%), and Norway (98%) (Darmawi *et al.*, 2013).

With an estimated 95% of population growth in the forthcoming decades, this increase in population will cause a greater migration to urban cities. The need for sustainable solutions with adequate and consistent power supply will be more in demand in years to come (Yuksel, 2010).

### ENERGY RECOVERY VENTILATOR (ERV) AND HEATING VENTILATION AND AIR CONDITIONING (HVAC)

A new energy strategy has been established to provide climate-specific recommendations that can help achieve energy savings. For instance, in the United States of America, 30% of the American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard have helped a lot in highway loading, small retail buildings, small hospitals, healthcare facilities, small office buildings, and small warehouses and self-storage buildings on how to utilize their energy (Jiru, 2014).

Energy Recovery Ventilators (ERV) is a very effective device that provides and improve our energy efficiency in building Heating, Ventilation and Air-Conditioning System (HVAC) systems. This is due to the precondition outdoor air it provides by transferring energy of both heat and moisture between outdoor ventilation air and indoor exhaust air (Rasouli *et al.*, 2013).

### ENERGY AND SUSTAINABLE DEVELOPMENT

All nations consider energy to be a necessity, but this is not the only major requirement for sustainable development. However, if at all any nation aspires to have sustainable development, it has to develop a sustainable supply of energy from diverse energy resources that are renewable and do not pose any danger to the environment (Abam, 2014).

Some ways by which a nation can provide energy with sustainable development is moving from finite sources of energy like fossil fuels such as coal and natural gas to unconventional sources like wind, solar power, biomass, hydropower and biofuels (Dincer and Rosen, 1999). These sources of renewable energy have long term sustainability. Sustainable development requires that energy must be used in an efficient possible way. With that, the society maximizes the benefits derived from utilizing its energy resources thereby minimizing the negative impacts such as environmental degradation which is associated with their use (Abam, 2014).

### ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

The environment in any nation has a greater concern and plays a significant role in sustainable development. Some activities degrade the environment and are not sustainable over a long period. The only way by which society can avoid the environmental problem is by looking for alternative sources of energy that have no or minimal environmental impacts (ECOWAS, 2015).

There is a strong link between energy efficiency and environmental impact. This is because fewer resources utilization and pollution is associated with an increase in energy efficiency. Improved energy efficiency help reduce energy loss. Most of the modern energy efficiency improvement has a positive impact on the environment. For instance, energy input requirements are reduced per unit output and more importantly reduced environmental impact (ECOWAS, 2015)

### ILLUSTRATIVE EXAMPLES OF ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Cogeneration which is also known as Combined Heat and Power (CHP), can help reduce the annual electricity consumption by 30%, which could allow the annual electricity generation to reduce by up to 47%. A CHP can generate power where it is required and also Greenhouse gases and other emissions which are caused by electricity utility could also give the chance to use the extra heat for heating and boilers (Romero and Diaz, 2015).

### CONCLUSION

The effort has to be made to reduce fossil fuels consumption and promote technologies that provide clean renewable energy for the sustainability of our society. This can be achieved by minimizing energy usage, recovering heat and use of more renewable energies. Renewable energy is a unique aspect of the devolved energy industry in the country and to enhance the advantages of renewable energy in Nigeria, it needs appropriate planning with a robust legal framework on renewable energy to encourage investment in the industry. For any society to have sustainable development use of energy must be minimized and all environmental concerns must be addressed to achieve the 2030 SDGs targets.

### RECOMMENDATION

To have a safer environment in which the level of pollution is minimized, the rate at which we are burning fossil fuels must be reduced. Moving into an electric vehicle could also be another option. All the renewable options must be harnessed to meet the energy demand of our societies. Rural electrification should be of paramount looking at the energy disparity from rural to urban areas. For any country to develop socially, politically, industrially and economically, there must be an adequate and consistent supply of electricity. Harnessing the renewable energy potential will go along in reducing the devastating effect of climate change, energy shortage as well pathways to a low-carbon future.

### REFERENCES

Abam, F.I., Nwankwojike, B.N., Ohunakin, O.S. and Ojomu, S.A. (2014). Energy resources structure and on-going sustainable development policy in Nigeria: a review. *International Journal of Energy and Environmental Engineering*. 5 (2): 1-16.

Ajayi, O. (2013). Sustainable energy development and environmental protection: Implication for selected states in West Africa. *Renewable & Sustainable Energy Reviews*. 26: 532-539.

Darmawi, Sipahutar, R. Bernas, S. & Imanuddin, M. (2013). Renewable energy and hydropower utilization tendency worldwide. *Renewable & Sustainable Energy Reviews*. 17 pp. 213-215.

Dincer, I. & Rosen, M.A. (1999). Energy, environment and sustainable development. *Applied Energy*. 64(1): 427-440.

Dincer, I. (2000). Renewable energy and sustainable development: A crucial review. *Renewable and Sustainable Energy Reviews*. 157-175.

ECOWAS, (2015). Sustainable Energy Policy and Investment High-Level Forum. *Africa Research Bulletin: Economic, Financial and Technical Series*. 52 (8): 20973C-20973C.

Global Climate, (2020). Provisional Report. World Meteorological Organization.

Hammond, G.P. (2000). Energy, Environment and Sustainable Development. *Process Safety and Environmental Protection*. 78(4): 304-324.

Jiru, T. (2014). Combining HVAC energy conservation measures to achieve energy savings over standard requirements. *Energy and Buildings*. 73: 171-175.

Okoye, C.O., Taylan, O. and Baker, D.K. (2016). Solar energy potentials in strategically located cities in Nigeria: resource assessment and PV system design. *Renewable and Sustainable Energy Reviews*. 55: 550-566.

Omer, A.M. (2008). Energy, environment and sustainable development. *Renewable and Sustainable Energy Reviews*. 12(9): 2265.

Rasouli, M., Ge, G., Simonson, C. & Besant, R. (2013). Uncertainties in Energy and economic performance of HVAC systems and energy recovery ventilators due to uncertainties in building and HVAC parameters. *Applied Thermal Engineering*. 50(1): 732-742.

Romero-Rubio, C. and Diaz, J. (2015). Sustainable energy communities: A study contrasting Spain and Germany. *Energy Policy*. 85: 397-409.

Shaaban, M. and Petinrin, J.O. (2014). Renewable energy potentials in Nigeria: Meeting rural energy needs. *Renewable and Sustainable Energy Reviews*. 29: 72-84.

Sivaramanan, S. (2015). Acid Rain, Causes, Effects and Control Strategies. Environmental Officer, Environmental Impact Assessment Unit, Environmental Management and Access Division, central Environmental Authority, Battaramulla, Sri Lanka. 15-20

Sivasakthivel, T. and Siva Kumar Reddy, K.K. (2011). Ozone Layer Depletion and Its Effects: A Review. *International Journal of Environmental Science and development*. 37-43

State of the Global Climate (2020). Provisional Report. World Meteorological Organization.

Thai-Ha Le and Nguyen, C.P. (2019). Is energy security a driver for economic growth? Evidence from a global sample. *Energy policy*. 129: 436-45.

Turner, J.A. (1999). A realizable renewable energy future. *Science AAAS*. 285(5428): pp. 687-689.

Ulrich, S. and Karl, W.B. (2010). Renewable Energies. *Desalination and Water Treatment*. 13:1-3.

Yuksel, I. (2010). Hydropower for sustainable water and energy development. *Renewable and Sustainable Energy Reviews*. 14(1): 462-469.