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Sustainable Energy

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ABSTRACT

Energy becomes sustainable if it meets the needs of the present without compromising the ability of future generations to meet their own needs. Some of the definitions of sustainable energy include the considerations of environmental aspects such as greenhouse gas emissions, social, and economic aspects such as energy poverty. Generally far more sustainable than fossil fuel are renewable energy sources such as wind, hydroelectric power, solar, and geothermal energy sources. Worthy of note is that some renewable energy projects, like the clearing of forests to produce biofuels, can cause severe environmental damage. The sustainability of nuclear power which is a low-carbon source is highly debated because of concerns about radioactive waste, nuclear proliferation, and accidents. The switching from coal to natural gas has environmental benefits, including a lower climate impact, but could lead to delay in switching to more sustainable options. "Carbon capture and storage" can be built into power plants to remove the carbon dioxide (CO2) emissions, but this technology is expensive and has rarely been implemented. Leading non-renewable energy sources around the world is fossil fuels, coal, petroleum, and natural gas. Nuclear energy is usually considered another non-renewable energy source, although nuclear energy itself is a renewable energy source, but the material used in nuclear power plants is not. The paper addresses the issue of sustainable energy, its attendant benefits to the future generation, and humanity in general.

KEYWORDS: *Sustainable energy, renewable energy, non-renewable energy, greenhouse effect, sustainable development, sustainability, smart grid*

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INTRODUCTION

The concept or idea on "sustainable energy" was brought to the global fore few years ago and since then it has gained prominence. This was as a result of climate change brought about by environmental pollution, caused by man's reckless exploitation of natural resources and release of harmful wastes, leading to global warming, greenhouse gas emissions, among others. The Intergovernmental Panel on Climate Change (IPCC) has estimated that 2.5% of global GDP equal to annual average investment of US$2.4 trillion in the energy system would be needed between 2016 and 2035 to limit global warming to 1.5 ^{o}C (2.7 ^{o}F). Now is the need for well-designed government policies that will promote energy system transformation to lower greenhouse gas emissions and improve air quality, as well as increase energy security. Other policy approaches should include carbon pricing, renewable portfolio standards, phase-outs of fossil fuel subsidies, and the development of infrastructure to support electrification and sustainable transportation. The burning of fossil fuels and biomass is a major contributor to air pollution, which causes an estimated 7 million deaths each year, therefore the need to transit to a low-carbon energy system for strong co-benefits for human health. The United Nations Brundtland Commission, in its 1987 report, defined sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their own needs." [1, 2].

Sustainability simply means the ability to maintain or support a process continuously over time. However, in business and policy contexts, sustainability seeks to prevent the depletion of natural or physical resources, so as to remain available for the long term. Due to concerns about anthropogenic climate change, biodiversity loss, and pollution becoming widespread, the world has shifted to embrace sustainable practices and policies, primarily through the implementation of sustainable business practices and increased investments in green technology. The three pillars of sustainability are economic, environmental, and social – also informally known as profits, planet, and people (the 3Ps) [3], as shown in Figure 1.

HISTORY OF SUSTAINABLE ENERGY

Historically, renewable energy could be traced back to ancient civilizations, which used the power of the sun, wind, and water for a variety of purposes. Ancient Greeks and Romans used wind-power water pumps to irrigate their crops, while the ancient Chinese and Persians used water wheels to grind grain. The widespread use of fossil fuels, coupled with the Industrial Revolution of the 18th and 19th centuries led to the decline in the use of renewable energy. The interest in renewable energy grew again during the 20th century due to the rise of the environmental movement and increasing concerns about the negative impacts of fossil fuels on the planet. The oil crisis in the 1970s led to a renewed focus on energy independence and the development of alternative energy sources. As a result of this, governments around the world started to invest in research and development of renewable energy technologies.

As at today, renewable energy is an established and growing industry, with many different technologies available, as shown in Figure 2. In 2022, according to the International Energy Agency (IEA), renewable energy sources represented about 26% of global power generation, and with a forecast to increase to 38% in 2027. Fossil fuels have continued to be the dominant source of energy. In 2019, coal, oil, and natural gas together represented about 78% of global primary energy consumption. There is the decline in recent years in the use of fossil fuels, and while in 2019, the CO_2 emissions from it decreased by 2%. According to IEA, it is expected that renewable resources will transform the global power mix through 2027 to become the largest source of electricity. Over 2022 – 2027, renewable resources are seen growing by almost 2,400 GW, equal to the entire installed power capacity of China. Renewable resources, as per the agency is expected to account for over 90% of global electricity capacity expansion over the five-year period [4].

CONCEPT OF SUSTAINABILITY

No single interpretation of how the concept of sustainability applies to energy has gained worldwide acceptance. However, the working definitions of sustainable energy encompass multiple dimensions of sustainability such as environmental, economic, and social dimensions [5].

Energy sources with low environmental impact are called green energy or clean energy. The economic dimension of sustainability covers economic development, efficient use of energy, and energy security to ensure that each country has constant access to sufficient energy [6], as shown in Figure 3.

According to Earth.Org, the year 2023 has gone down in history as the hottest, with global average temperatures at 1.46 ^{o}C above pre-industrial levels and 0.13 ^{o}C higher than the eleven-month average for 2016, which is currently the warmest calendar year on record. The highly controversial UN climate summit (COP28} (held from 30th November – 13th December, 2023 in Expo City, Dubai, in the United Arab Emirates) ended with a deal that saw countries commit to moving away from fossil fuels for the first time in history [7]. As valuable as fossil fuels are as a source of energy, burning it is harmful to the environment. The particles of coal and oil released when burnt can pollute the air, water, and land. The burning of fossil fuels also upsets the Earth's "carbon budget" which balances the carbon in the ocean, earth and air. When fossil fuels are combusted i.e. heated, they release carbon dioxide into the atmosphere. Carbon dioxide is a gas that keeps heat in the earth's atmosphere, a process called the "greenhouse effect." The greenhouse effect is necessary to life on earth, but it relies on a balanced carbon budget. The removal of the sequestered carbon (i.e. the carbon in fossil fuels that has been stored underground for millions of years) and being released into the atmosphere causes the Earth's carbon budget to fall out of balance – causing temperatures to rise faster than organisms can adapt [8].

APPLICATION OF SUSTAINABLE ENERGY

The introduction of artificial intelligence (AI) into the new era of renewable energy systems and smart power grid modernization is changing slowly. Cloud-connected artificial (AI) technologies like machine learning, data analytics, and the Internet of Things (IoT) are driving the advancement of smart grids capable of managing far more complex power generation and distribution, as shown in Figure 4. These technologies herald significant opportunity for those in the complex energy ecosystem that are able to harness them. Energy prosumers (prosumer is a word combining "producer" and "consumer")

typically remain connected to the central grid, who are capable of producing and even storing energy – typically with photovoltaic solar panels and EV batteries.

A smart grid is a network that integrates energy distribution and digital communication technology in a two-way flow of electricity and data, which enables utility companies to optimize the generation, transmission, and distribution of electricity [9].

Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation. We can make use of sustainability tips like, which is reducing your carbon footprint by limiting your energy use, and consume less. Any behavior that conserves resources, such as recycling as an example, will reduce greenhouse gas pollution. Some practical ways to cut greenhouse gas emissions are [10]:

- Unplug your electronics as many appliances consume energy even when not in use. This is called "phantom load," and can cost you $100 per year.
- Adjust your thermostat.
- Alter your driving habits.
- Green-clean your clothes.
- Eat lower on the food chain.
- Consider travel alternatives
- Don't skip tune-ups.
- Make conscious purchases.
- Rethink your waste, and
- Prioritize efficiency.

Nokia's innovative AI solutions include [11]:

1. Energy efficient AI base station – Cutting-edge solution uses of hard math to find the best balance between network performance and energy consumption.
2. Intelligent wildlife alarm – Environmental monitoring solution tracks rainforests and oceans with continuous AI/ML-generated insights.
3. Telecom equipment now being powered by healthier sources from next-generation batteries as backup – this is tremendous innovation towards more green sources of energy.

BENEFITS OF RENEWABLE ENERGY USE

Sustainable energy such as wind and solar energy creates zero carbon emissions that can harm the atmosphere and contribute to global warming. It offsets the need for fossil fuels, which are actively increasing climate change and polluting our earth, as shown in Figure 5. Maintaining the right balance between supply and demand is no small task – this is precisely where artificial intelligence (AI) steps in, proving its significance by optimizing sustainable energy generation and resource allocation [12]. Sustainable energy is the urgent solution required to save the environment and combat global warming.

Some of the derivable benefits of renewable energy use are:

1. The global warming emissions associated with renewable energy are minimal, from the "life cycle" emissions of clean energy (i.e. emissions from each stage of a technology's life – manufacturing, installation, operation, decommissioning) [13].
2. Improved public health: Most of the negative health impacts come from air and water pollution that clean energy technologies simply do not produce. Wind, solar, and hydroelectric systems generate electricity with no associated air pollution emissions. The U.S. is exploring the implications and challenges of very high renewable electricity generation levels – from 30% up to 90%, focusing on 80%, of all U.S. electricity generation – in 2050 [14], as shown in Figure 6. It is not just beneficial for the environment but also for public health. It reduces harmful emissions, does not contaminate water supplies, and is inexhaustible.
3. Jobs and other economic benefits: More jobs would be created for each unit of electricity generated from renewable sources than from fossil fuels as in the United States [15 – 18]. Hydropower is the largest renewable energy source deployed in the U.S. that could create 1.4 million jobs [19]. The local governments will as well benefit in the form of property and income taxes and other payments from renewable energy project owners [20], as shown in Figures 7 and 8.
4. Stable energy prices: Renewable energy would provide affordable electricity across the country and help stabilize energy prices in the future. The costs of renewable energy technologies are also steadily declining [21].
5. Reliability and resilience: Wind and solar are less prone to large-scale failure because they are distributed and modular [22].

CHALLENGES/BARRIERS TO SUSTAINABLE ENERGY

Some of the challenges or barriers to sustainable energy include:

1. Technical barriers in efficient energy storage and infrastructure requirements.
2. Economic challenges in adopting renewable energy in terms of high upfront investment costs and competition from fossil fuels.
3. Regulatory hurdles, such as complex permitting processes and inconsistent policy standards that

are slowing down the adoption of renewable energy. This is as a result of lack of policies, subsidies, incentives and regulations that favor renewable energy technologies hindering its wide acceptance.

4. High initial cost of installation.
5. Non-renewable energy monopoly.
6. Lack of knowledge and awareness of renewable energy technology makes people reluctant to use it.

Hindrances are due to corporate lobbying, political pressure, and inherent dependence on fossil fuels. However, with the governments being aware of these challenges and working to streamline the process, we are on the right path toward a future powered by clean, sustainable energy, which are eco-friendly power sources [23, 24].

CONCLUSION

Energy plays vital role in the economic growth, progress, and development, as well poverty eradication/reduction and security of any nation. Access to clean modern energy services is a great challenge facing the African continent because energy is fundamental for socioeconomic development and poverty eradication. As at today, 60-70% of the Nigerian population lack access to electricity. This trend will persist unless the three tiers of government garner the political will to diversify the energy sources in domestic, commercial, and industrial sectors and adopt new available technologies to reduce energy wastages, save costs and to save/protect our environment by keying into green energy. Africa and indeed Nigeria, need to urgently start investing in renewable sources of energy from solar, wind and water.

More information about sustainable energy can be found in the books in [25-28].

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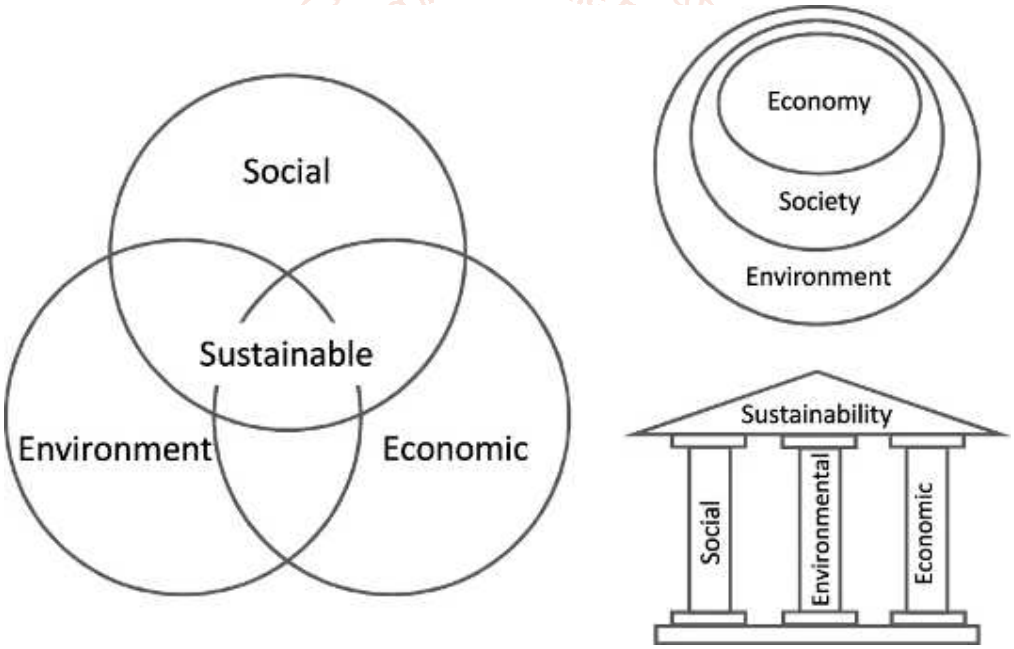

Figure 1. Sustainability - Wikipedia

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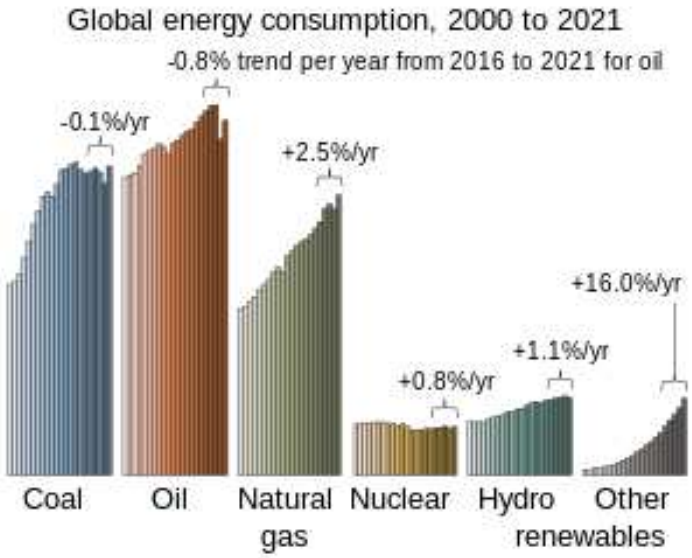

Figure 2: Renewable energy - Wikipedia

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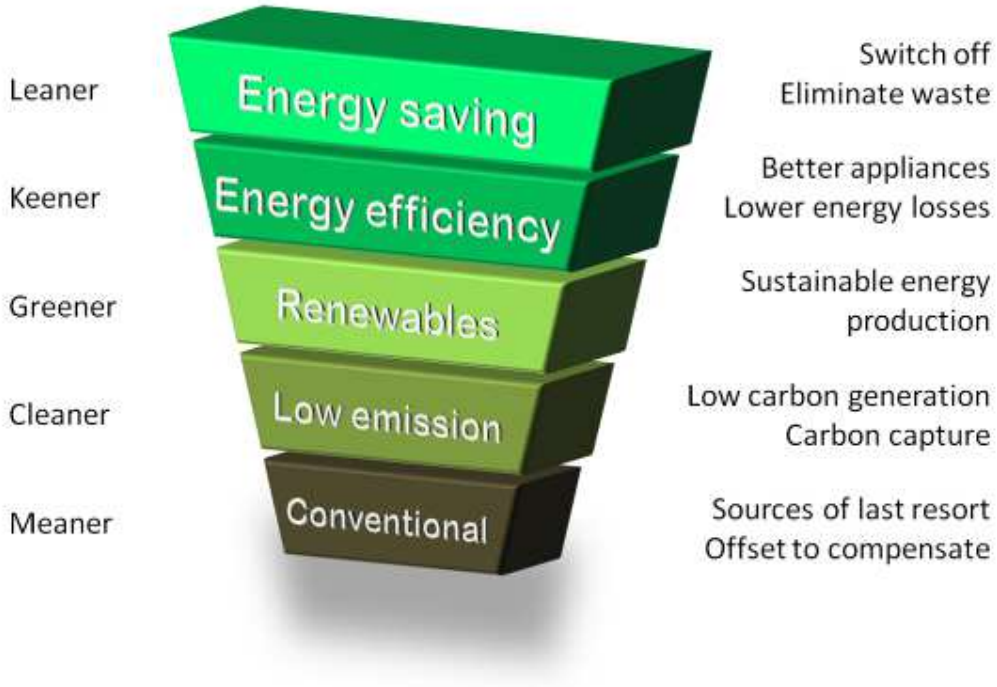

Figure 3: Energy hierarchy - Wikipedia

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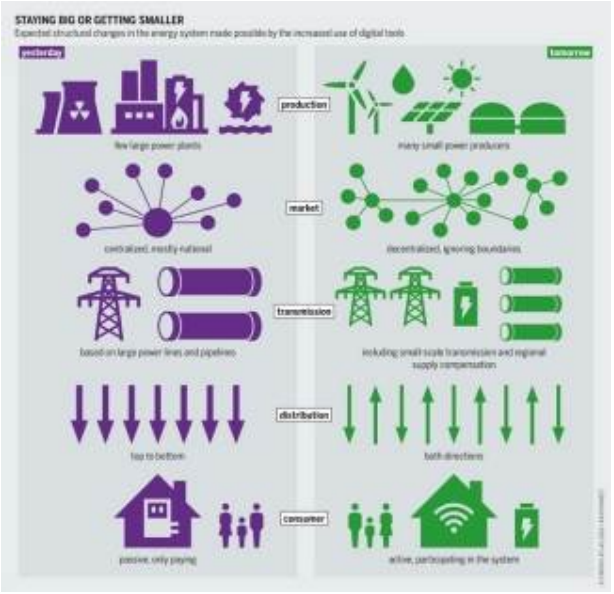

Figure 4: Smart grid - Wikipedia

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Figure 5: Climate change mitigation – Wikipedia

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Figure 6: Renewable energy sources I Alternative energy sources - Wiki

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Figure 7: Sustainable energy - Wikipedia

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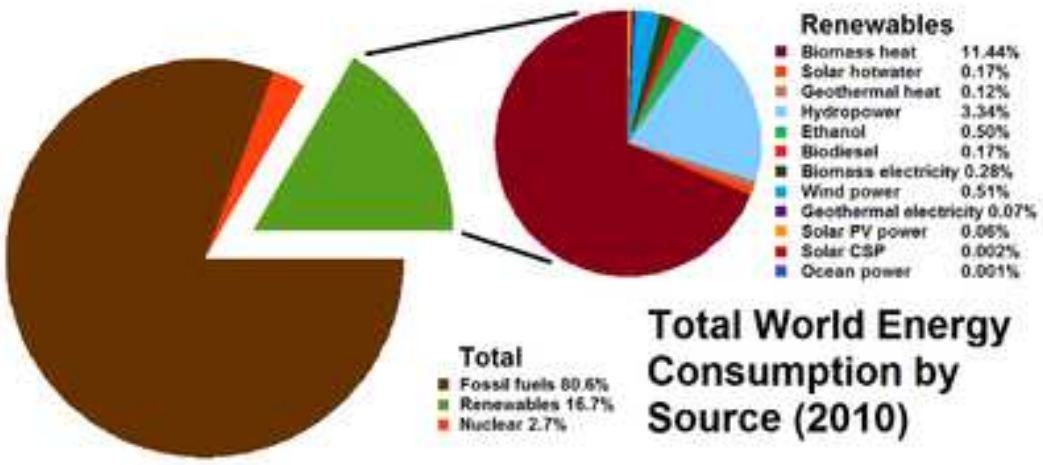

Figure 8: Energy development - Wikipedia

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