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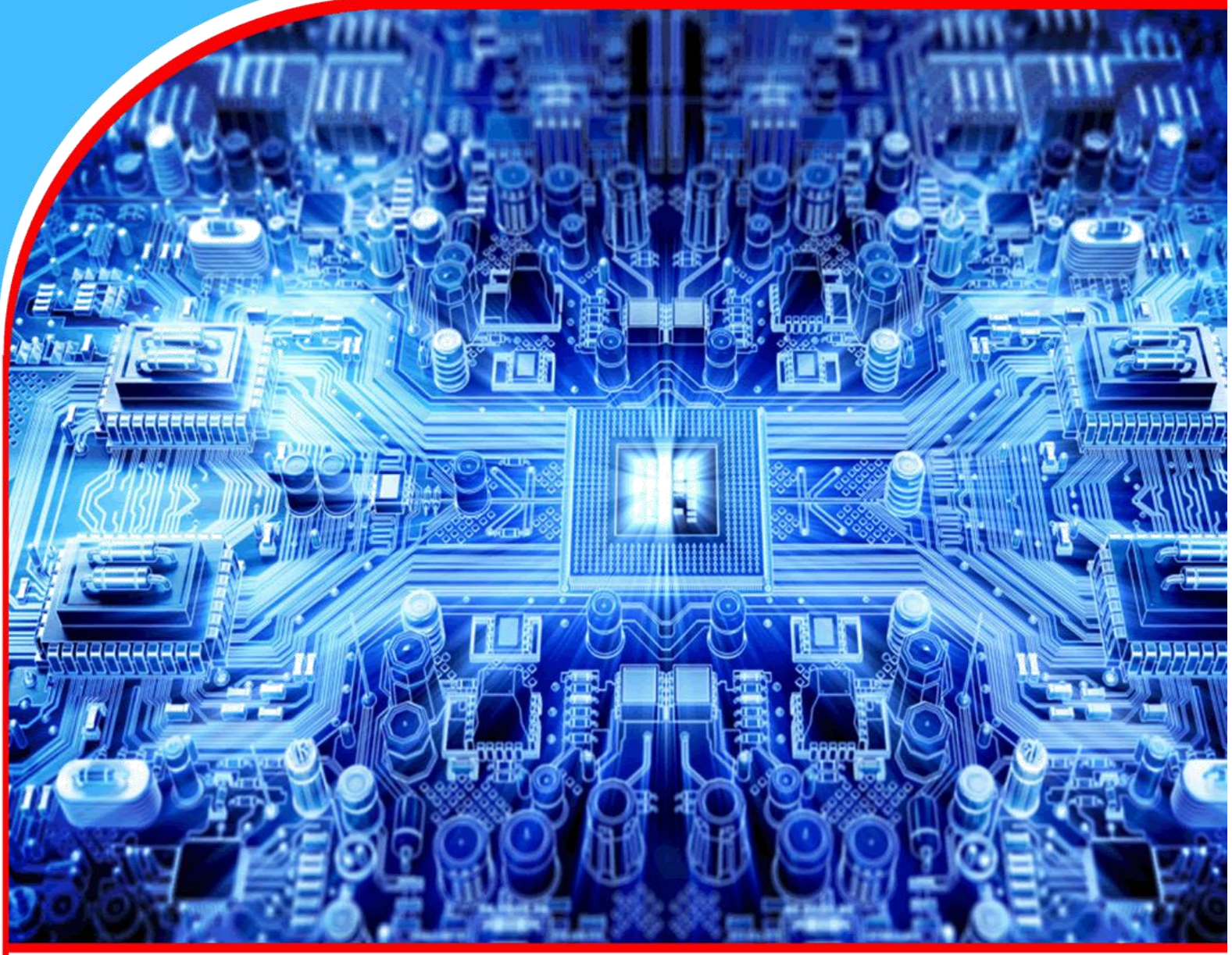

Decarbonization, Opportunities and Dilemma for Developing Countries

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Abstract

Purpose: The purpose of this paper is to analyze the dilemma of third world countries in the decarbonization policy drive by drawing a comparison of power generated by third world countries and quantity of CO_2 emissions against that of first world nations to ascertain third world nations' CO_2 emissions.

Materials and Methods: This is achieved by conducting an extensive literature review, conducting questionnaires, and conversing with industry experts aimed at identifying and comparing sources of power generation and consumption by third-world countries and developed countries. Analysis of collected data is conducted by statistical methods to arrive at conclusive deductions regarding the implications and opportunities available for decarbonization.

Findings: The study revealed that fossil fuel still constitutes about 64% of energy generation and over 80% of the carbon dioxide (CO_2) generated by human activity (around 35 billion tonnes a year) comes from burning fossil fuel. This paper proposes unique practical solutions that would ensure a smooth transition during decarbonization like unbundling the national grid and power infrastructure to create smaller and more efficient microgrids (energy efficiency), improving the energy efficiency of existing power infrastructure, proper short, midterm and long-term Government policies on energy, investments in renewable technologies like solar, wind and Nuclear, acquisition of energy storage systems, transparency to curb corruption), and more investment in homegrown technological drive.

Implications to Theory, Practice and Policy: Conclusively, policymakers are encouraged to take necessary steps to ensure that decarbonization can be achieved without significant challenges on infrastructural growth and development.

Keywords: *Decarbonization, Energy, Energy Efficiency, Greenhouse Emissions, Renewable Energy*

1.0 INTRODUCTION

The world as a thriving global economy requires energy (Bhuiyan et al., 2022). In other words, all sectors of today's society are directly or indirectly linked to economic growth and development which in turn necessitates using some form of energy. Cumulatively in today's 21st century, energy consumption has been growing significantly over the years. According to the 2014 key world energy statistics released by the International Energy Agency (IEA), about 13,371 Exajoules (EJ) of energy were generated and supplied globally in 2012. This total global primary energy consumption (PEC) was increased to 557 Exajoules (EJ) in 2020, with Renewable energy generation accounting for 6% (32 Exajoules), while fossil fuel consumption was 463 EJ (or 83% of Primary Energy Consumed). The remainder was accounted for by nuclear energy and hydroelectricity (BP, 2021). Although there is an increasing trend in global energy generation and supply, the percentage share of fossil fuel has by far remained the highest. This implies the sustained use or combustion of fossil fuels for the generation of electricity.

One of the effects of fossil fuel combustion for energy generation is the liberation of CO_2 into the atmosphere. These CO_2 emissions from fossil fuels have been identified as a major global environmental threat due to its contribution to global warming (Friedlingstein *et al*, 2022). For the past years, various measures or efforts have been made to reduce CO_2 emission and so mitigate the associated environmental impact. This is because most of the generating power stations of national grids (for most first and third nations alike) are still mainly powered using coal, diesel and gas turbines which are basically responsible for the emission of ozone depleting greenhouse gases to the atmosphere. In the wake of drastic climatic changes and global warming due to fossil fuel combustion, the situation has become worrisome and in need of urgent action. To mitigate these effects of CO_2 on the environment and global warming, the policy of carbon reduction measures (decarbonization) became a trend.

As such, the global energy transition, that is the full decarbonization of the world energy system until 2050, has been attracting growing attention in global policy debates. The race toward maintaining atmospheric temperature rise to 1.5ºC above pre-industrial levels requires the collaborative contributions of all nations of the world—from low-income to high-income economies. While this is a bit easier for first-world nations to key into the decarbonization policy given their huge financial capability and technological expertise, the same cannot be said for third-world nations. Even more worrisome is the fact that almost all third-world nation means of generating power are fossil-based with very little of renewable energy sources when compared to advanced nations increasing use of renewable energy sources. Given the limited resources of third-world nations and the already massive investments in fossil fuel infrastructure for power generation plus weak technological know-how, the one-million-dollar question that continues to resound in the face of third-world nations adhere to the decarbonization shift is: How can third-world countries constructively maintain a balance between the energy transition drive and sustainable energy growth? In other words, in the wake of shifting economic constraints and conflict, how best can first-world countries prioritize and enable a just energy transition (decarbonization) while meeting millennium development goals? This discussion is important for two reasons: (1) It will highlight the role fossil fuel for power generation still plays even within the energy mix of advanced or first world nations as a means or countering the drive that third world nations should leapfrog into the decarbonization policy timeline.

Third-world nations need energy and as such should not be made to pay the price of decarbonizing policy as there appears to be inadequate affordable energy investment and mitigation finance for third-world nations. It is well known that the energy transition comes at a high financial cost to all economies, and those with higher financial resources may transit earlier and more easily (Dioha & Kumar, 2020). (2) Also, there is still no study on how developing countries can participate in the transition in an affordable manner, without sacrificing their potentials for growth and development. per intends to close these research gaps by a critical overview of possible solutions (weather technological or policy framework) for the third world nations timely participation in the clean energy transition without sacrificing economic growth potentials. Papadis and Tsatsaronis, (2020) conducted a review of the challenges of decarbonization in the global space. They reviewed the historical development of decarbonization process and access the various technological options for smooth transition. They further analyzed the inherent challenges that is expected which could be environmental, technical, economic and social. They concluded that decarbonization cannot be achieved in the 21st century, due to capital investments required, inconsistent government and environmental policies and political bigotry.

Treut et al., (2021) conducted literature review of the proposed Deep Decarbonization Pathways Project formulated by a collaborative effort of 16 countries. They constructed a conceptual framework for DDPP analysis, incorporating policies priorities, national characteristics and model-agnostic principles that drive innovative changes in developing countries. Nyangarika et al., (2022) discussed the decarbonization and energy stability of developing countries, by applying a random forest distribution. They performed real-time monitoring and forecasting of crude oil trade flows, hence identifying sources of CO_2 emissions, and possible solutions. They confirmed that developing countries continue to opt for fossil fuel rather than renewable energy sources, which continues to bring devastating effects to the environment. To preserve the ecosystem, and our very existence, deep decarbonization modelling cannot be over-emphasized in the foreseeable future.

The aim of this paper is to analyze the dilemma of third world countries in the decarbonization policy drive by drawing a comparison of power generated by third world countries and quantity of CO_2 emissions against that of first world nations to ascertain third world nations CO_2 emissions. This is achieved by conducting extensive literature review, conducting questionnaires and conversing with industry experts aimed at identifying and comparing sources of power generation and consumption by third world countries and developed countries. Analysis of collected data is conducted by statistical methods to arrive at conclusive deductions regarding the implications and opportunities available for decarbonization.

2.0 MATERIALS AND METHODS

This Paper addresses the challenges, opportunities and dilemma of decarbonization in developing countries. Extensive literature review of decarbonization policies, challenges in implementation and dilemma developing countries are faced with in transitioning towards decarbonization is conducted. Data is statistically collected from literature which is validate by IPPC (intergovernmental panel on climate change) and then analyzed to arrive at concise deductions on possible solutions to swift transition. The following steps are taken:

i. Literature review of the challenges and opportunities present for decarbonization in developing counties is conducted.

ii. Data collection: developing and developed countries power consumption and quantity of CO_2 emissions are collected,

iii. The data are compared against each other to identify impact of developing countries on global warming.

iv. Challenges for swift decarbonization in developing countries are highlighted, which are environmental, social, technological and economic.

v. Possible solutions towards swift and easy transition are proposed.

Energy Status

Energy demand has increased in both developed and developing countries in recent decades. on the increase in third world countries who hitherto are yet to fully key into the decarbonization push of first world countries. While developed countries' living standards have broadly improved, developing countries have lagged in matching energy supply with energy demand due to increasing living standards, population, urbanization, and industrialization (Bhattarai et al., 2022). For the poorest of the poor, the real need is electricity access, regardless of fuel. Sub-Saharan Africa is where most people lacking modern energy services live. Around 790 million people in developing countries lack access to electricity, and 2.6 billion rely on polluting fuels such as wood or charcoal to cooking in a bid to bridge this divide, third world countries are investing massively into the energy generation and distributing sector. Figure 1 shows that coal and gas (both fossil fuels) still leads global energy consumption.

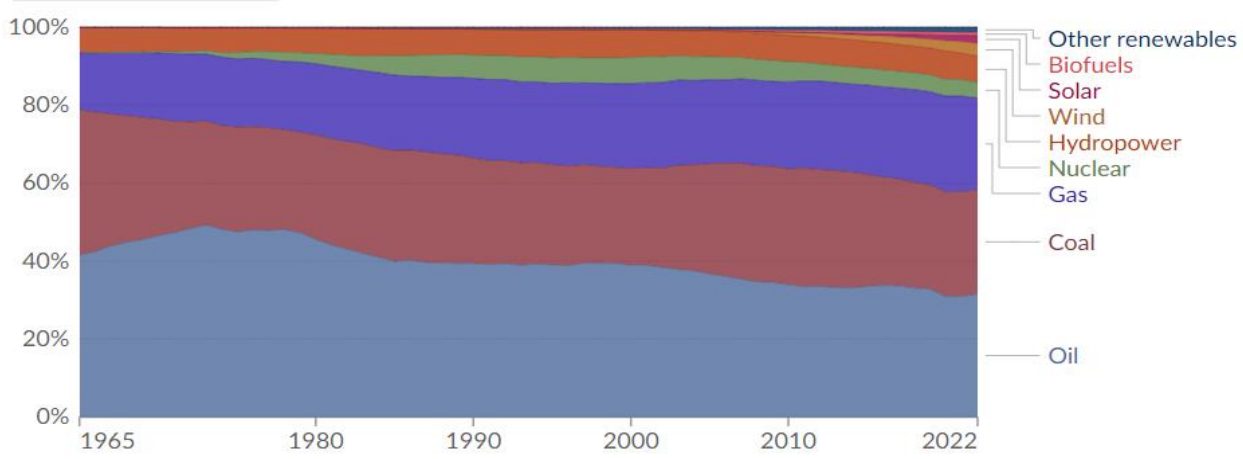

Figure 1: Global Energy Consumption (Energy Institute - Statistical Review of World Energy, 2023)

Most of the generating power stations of national grids (especially for third world nations) are still mainly powered using coal, diesel and gas turbines which are basically responsible for the emission of ozone depleting greenhouse gases to the atmosphere as shown in Figure 2.

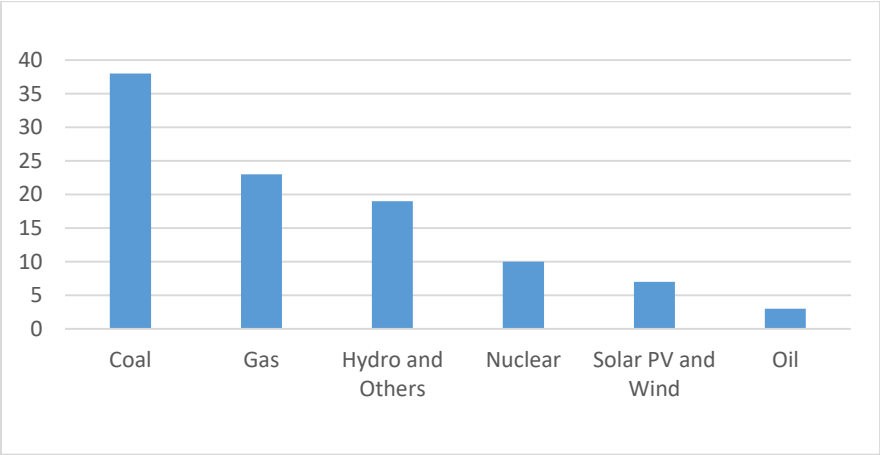

Figure 2: 2018 World Electricity Generation (IEA, 2019)

Global energy consumption, measured in exajoules per year: Coal and natural gas remain the primary global energy sources even as renewables have begun rapidly increasing. As of 2022, energy consumption is still about 80% from fossil fuels (Vera *et al*, 2007*).* Meeting existing and future energy demands in a sustainable way is a critical challenge for the global goal of limiting climate change while maintaining economic growth and enabling living standards to rise. Reliable and affordable energy, particularly electricity, is essential for health care, education, and economic development. As of 2020, 790 million people in developing countries do not have access to electricity, and around 2.6 billion rely on burning polluting fuels for cooking (Babayomi and Dahoro, 2021). With respect to third world nations, this is challenge that must be addressed to meet energy sustainability goal. In terms of renewable energy generation, comparing installation capacity of third world nations to that of first world nations shows a wide divide. For instance, Africa accounted for only 1.3% (586,434MW) of the global installed solar capacity in 2019. In Asia, the situation is similar: excluding China, India, Japan, and South Korea, Asian countries accounted for only 5.4% (330,786 MW) of the total installed solar capacity of (IRENA, 2021a). In the wind energy sector, Africa boasts only 0.9% of the global installed wind capacity in 2019. In Asia, excluding China, India, Japan, and South Korea, the total installed wind capacity is 2.0% of the global sum (IRENA, 2021a). These renewable energy differences in values highlight the slow pace of the energy transition of developing nations.

Greenhouse Emissions

A serious problem concerning energy production from fossil fuels and consumption is greenhouse gas emissions. In 2019, 84% of primary energy consumption in the world and 64% of its electricity was from fossil fuels (Le Treut *et al*, 2021*).* Over 80% of the carbon dioxide (CO_2) generated by human activity (around 35 billion tonnes a year) comes from burning fossil fuel, compared to 4 billion from land development. Of about 50 billion tonnes worldwide annual total greenhouse gas emissions, 36 billion tonnes of carbon dioxide was emitted due to energy (almost all from fossil fuels) in 2021 (Hasanov et al, 2021). One of the biggest debates at the United Nations climate summit in Glasgow is whether — and how — the world's wealthiest nations, are disproportionately responsible for global warming to date, and as such should compensate poorer nations for the damages caused by rising temperatures. Figure 3 shows a historical time of CO_2 emissions and it shows distinctly that first world nations (developed nations indicated in blue) have

contributed more to global warming due to their greenhouse emissions which is by far higher than that of third world nations.

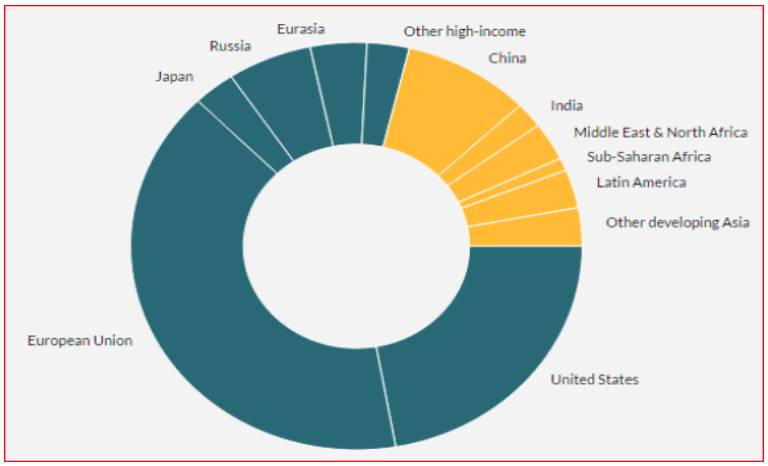

Figure 3: Historical CO_2 Emissions (https://www.cgdev.org)

According to Popovich and Plumer (2021) rich countries, including the United States, Canada, Japan and much of western Europe, account for just 12 percent of the global population today but are responsible for 50 percent of all the planet-warming greenhouse gases released from fossil fuels and industry over the past 170 years. From the current perspective, China, home to 18 percent of the world's population, is responsible for nearly 14 percent of all the planet-warming greenhouse gases released from fossil fuels and industry since 1850. But today it is the world's largest emitter by far, accounting for roughly 31 percent of humanity's carbon dioxide from energy and industry this year (Popovich and Plumer, 2021). Figure 4 shows a further breakdown of greenhouse emissions by country.

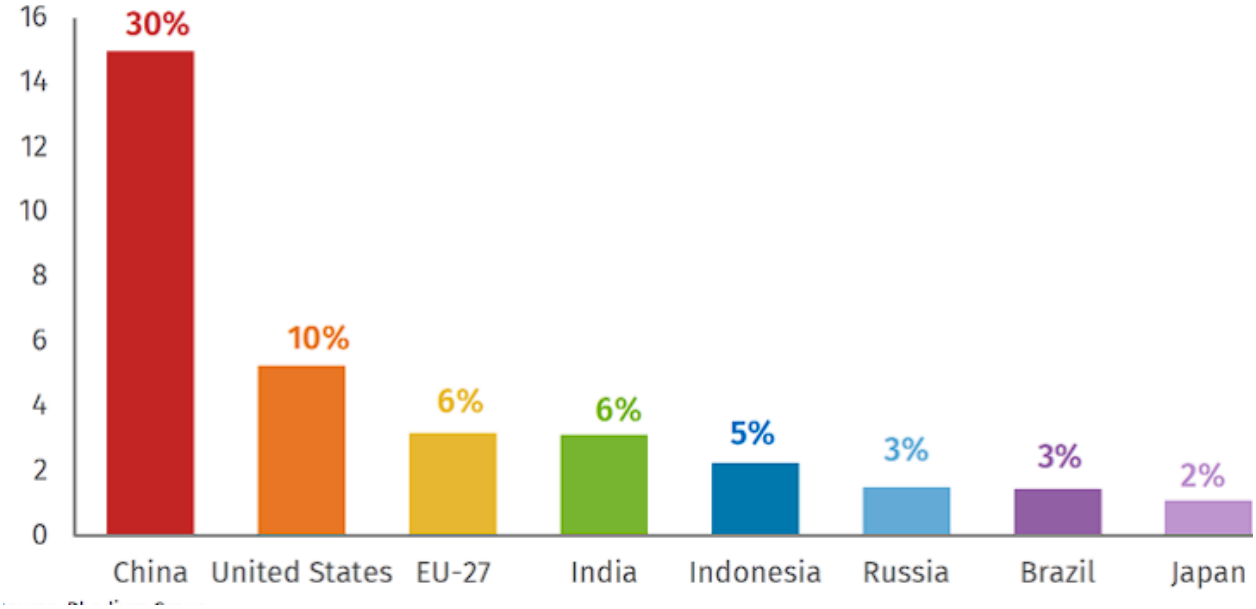

Figure 4: Total Emission of CO_2 Gt in 2020 (https://rhg.com/research)

If current trends continue, in other words, if the current share of fossil fuels is maintained and energy demand nearly doubles by 2050, emissions will greatly surpass the amount of carbon that can be emitted if the global average temperature rise is to be limited to 2ºC. That level of emissions would have disastrous climate consequences for the planet.

The Decarbonization Policy

Decarbonization is the process of reducing or eliminating carbon dioxide emissions from energy sources through the use of technology, life cycle assessments, and both required and optional actions to minimize carbon dioxide emissions. (Duangphastra, 2020). It is simply the goal of ending the dependence on oil and gas as power sources to reduce the carbon dioxide (or CO2) emissions that raise global temperatures. The aim of stabilizing climate change at around 2°C above preindustrial temperatures has been set by world leaders; to meet this goal, carbon emissions must be eliminated from the planet by the year 2100 (Marianne et al., 2015). Although climate change and its impact could not be prevented by world communities, either developed countries or developing countries could work together. Within the limits of Poorer, vulnerable countries have asked richer nations to provide more money to help adapt to these hazards. Fossil fuel phase-out, a gradual reduction in fossil fuels consumption is an effective intervention capable of improving health and reducing diseases, mortality, and air pollution (Lelieveld et al., 2023)

Measures for Sustainability Goals

Energy is sustainable if it "meets the needs of the present without compromising the ability of future generations to meet their own needs (Kutscher, 2019). Sustainable Development Goal calls for "access to affordable, reliable, sustainable and modern energy for all", including universal access to electricity and to clean cooking facilities by 2030. With limited or tight financial constraints of third world nations, the need to reduce emission cannot preclude the use of fossil fuels, but will require a significant change in direction and business. Energy efficiency and renewable are often positioned as the only solutions needed to meet climate goals in the energy system, but they are not enough. Including an expansion of the use of carbon capture systems (CCS) will be essential, and this technology is expected to result in 16 per cent of annual emissions reduction by 2050. In view of the massive investments of third world nations in fossil fuel generation of electrical power, it cannot be expected that third world nations should leap frog into the decarbonization policy of yesterday just because first world nations are pushing for it.

From already reviewed literature, first world nations have contributed about 60% to the quantity of greenhouse emissions to the atmosphere and as such should do more in assisting poorer nations in the decarbonization policy drive. (Shukla 1999) claimed that the distribution of world funding, military stock, knowledge and natural resources is controlled by the developed nations. The power of developed countries in bargaining the world economy had a great influence on the developing countries. Actually, the Kyoto Protocol in 1996 has already recommended developed countries to have commitments in alleviating the impact of climate change especially in lessening carbon emission (Harte et al. 2000). This unfortunately is not the current scenario as most of the first world nations have failed to meet up their pledged financial commitments. It can be argued that developing countries have limits and insufficient financial capacity compared to developed nations. This situation has direct effect on developing countries dealing with climate change impact. In the wake of such indifferent attitude from first world nations, third world must then look for proactive pathways that exist to provide universal access to electricity and clean cooking

in ways that are compatible with sustainable climate goals while bringing major health and economic benefits to include.

Government policies: Well-designed government policies that promote energy system transformation can lower greenhouse gas emissions and improve air quality simultaneously, and in many cases can also increase energy security and lessen the financial burden of using energy. Short, midterm and long-term policies are needed to incentivize investments in decarbonized infrastructure that can accelerate energy system transformation by leading the development of infrastructure such as long-distance electrical transmission lines and smart grids. In transport, government policies appropriate infrastructure and incentives can make travel more efficient and less car-dependent. To this end, third world countries should consider tax reliefs for private investors in this regard.

Energy efficiency: Using less energy to deliver the same goods or services or delivering comparable services with less goods—is a cornerstone of many sustainable energy strategies. The International Energy Agency (IEA) has estimated that increasing energy efficiency could achieve 40% of greenhouse gas emission reductions needed to fulfil the Paris Agreement's goals (IEA, 2018). Energy can be conserved by increasing the technical efficiency of appliances, vehicles, industrial processes, and buildings. This implies that third world nations must improve on their overall energy efficiency in order to minimize losses and meet its drive for sustainable energy for all. Government policies to improve efficiency can include building codes, performance standards, carbon pricing, and the development of energy-efficient measures that includes district cooling systems that cool multiple buildings with piped cold water as an alternative to air conditioning that requires large amounts of electricity and is not always affordable for poorer and measures like unbundling of the national grid and power infrastructure to create smaller and more efficient micro–grids (Babayomi et al., 2020). The use of solar rechargeable induction cookers will also go a long way improving energy efficiency of available electrical power.

Solar energy: Renewable energy source like solar is essential to sustainable energy, as they generally strengthen energy security. In 2019, solar power provided around 3% of global electricity, (Van *et al*, 2021) mostly through solar panels based on photovoltaic cells. Although intermittent in its availability and would mostly require energy storage system, a decentralized renewable energy such as solar-powered mini-grids is likely the cheapest method of providing sustainable energy goals to the more than half of the 770 million people who currently lack access to electricity in third world nations (. Technologies Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear fresnel reflector, the Stirling dish and the solar power tower. Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage (Gonzalez *et al*, 2021).

Wind Energy- Wind has been an important driver of development over millennia, providing mechanical energy for industrial processes, water pumps, and sailing ships. Renewable energy source like wind can also be integrated as an essential and sustainable energy source for small to medium-sized projects. This can be integrated into the agricultural sector where it can be utilized for small farming operations that hitherto had been run on fossil fuel generator sets.

Biomass Energy—third world nations can also direct their attention to the utilization of biomass, which is energy produced from waste products such as rice husks, animal waste, and crop residue. Biomass is renewable organic material that comes from plants and animals. It can either be burned to produce heat and electricity or be converted into biofuels such as biodiesel and ethanol, which can be used to power vehicles (Kweka *et al*, 2021). Improved cook stoves that burn biomass more efficiently than traditional stoves can serve as an interim solution where transitioning to clean cooking systems is difficult.

Natural Gas— Developing nations need energy, which may require little fossil fuel. in view of the abundant natural gas reserves available in third world nations, it becomes imperative that third world nations invest more in natural generating systems so as to meet its millennium development goals in terms of sustainable energy for its teeming citizen who still lack access to a good supply of electrical energy. it must be understood that in the context of third world nations, the decarbonization policy drive doesn't imply that fossil fuels and cleaner energy sources are mutually exclusive. As such, renewable energy alone will not be practical or sufficient to meet energy needs of third world nations. To this end, strategically deploying energy source like natural gas could make it easier and faster at meeting sustainable energy goals while adding up to an overall reduction in greenhouse gases. Burning of natural gas produces roughly half of the greenhouse gases emitted per quantity of energy and as such is cheaper to install. General electric (USA) has designed an innovative 100KVA generator in a truck that uses natural gas and can be installed and connected to any mini grid within the shortest possible time.

Hydroelectric Energy-- Hydroelectric Energy plants convert the energy of moving water into electricity. In view of the constant flooding in most third world nations, hydroelectric plants with large water reservoirs can be built to harness this massive body of water for the generation of electrical energy for sustainable energy demands. In 2020, hydropower supplied 17% of the world's electricity and as such constitute a viable energy alternative to the use of fossil fuels. Hydropower ranks among the energy sources with the lowest levels of greenhouse gas emissions per unit of energy produced.

Distributed generation: This is the local generation of energy near or at the site where it will be used. The primary benefit of this system is the potential to supply excess locally generated power to the grid at a grid feed-in tariff, giving the owners alternative sources of income.

Economic diversification: Majority of the leading oil producer economies are developing countries, with oil exports accounting for the significant part of their gross domestic product (GDP). Since several leading net-importers are already increasing the share of alternative low-carbon fuels in their energy mix, the demand of oil will decrease significantly around 2030 when such fuels move from validation state to commercial scale. It is essential that producer economies diversify economic sources urgently to reduce the impending socio-economic pressures that would arise from loss of major revenues.

Carbon offset market: Through legislation, incentives, and mechanisms such as the Clean Development Mechanism (CDM) established under the Kyoto Protocol and further emphasized in discussions at the Conference of the Parties (COP) meetings, developed countries can fund carbon reduction projects in developing countries to offset their own emissions. This not only helps in global CO_2 reduction but also supports sustainable economic development in third world countries. For instance, COP26 in Glasgow highlighted the urgent need for increased financing for climate

action in developing countries, emphasizing the role of carbon markets in achieving global net-zero emissions. These efforts underscore the importance of international cooperation and the need for developed nations to support developing ones in the transition towards a greener economy, reflecting a shared but differentiated responsibility in addressing climate change. COP28 summit included a high-level roundtable on developing a global carbon market architecture. However, negotiations on an organized, UN-overseen carbon market failed. The failure was due to a deadlock between countries that wanted Article 6 carbon markets to be available with few restrictions and countries that wanted to uphold transparency, human rights, and climate ambition.

3.0 CONCLUSION AND RECOMMENDATIONS

Fossil fuels provide 85% of the world's energy consumption, and the energy system is responsible for 76% of global greenhouse gas emissions. Around 790 million people in developing countries lack access to electricity, and 2.6 billion rely on polluting fuels such as wood or charcoal to cook. Reducing greenhouse gas emissions to levels consistent with the 2015 Paris Agreement will require a system-wide transformation of the way energy is produced, distributed, stored, and consumed. The burning of fossil fuels is a major contributor to air pollution, which causes an estimated 7 million deaths each year. For third-world nations, quite a few of mitigating measures ranged from creating new and innovative energy conversion technologies (renewable energies) to improving the efficiency of existing energy conversion technologies. Wind and solar power are already the cheapest sources of new energy in much of the world, and they can get up and running faster than just about anything else. They are particularly beneficial for some of the most remote communities, where it's difficult to build out the roads and power lines needed to support large, central power stations (Oyewo, et al, 2021). Furthermore, reducing energy wastage from a variety of industries whether domestic or commercial by storing them for future use has a very significant impact in reducing CO_2 emission. Although financial and technological support is highly desired from developed nations, third-world nations must engage in proactive measures that will enable sustainable energy development while striving to key into the decarbonization policy drive. It is recommended that policymakers, practitioners, and government regulators should invest in renewable energy sources, as outlined in this paper. A conceptual framework for implementation should be established and coordinated with a regulatory framework for (supervision) that would ensure major stakeholders are well informed of steps in transitioning, swiftly while ensuring sustainable economic and infrastructural growth and development. The transition phase energy required to fuel the economy should be invested in and exploited by multinational companies to ensure the price for energy remains at an affordable rate during the decarbonization. There is a huge opportunity to profitably harness the carbon markets as green project destination, thereby boosting economic development, gross domestic product (GDP) and foreign direct investment (FDI)

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