International Journal of Management and Commerce Innovations ISSN 2348-7585 (Online)
Vol. 9, Issue 2, pp: (537-557), Month: October 2021 - March 2022, Available at: www.researchpublish.com

The Current Energy Transition and the economies of Mineral Energy Materials (MEM) Exporting Countries: A Case for Nigeria

Dr. Amieyeofori Valentine Felix, Ph.D

ENERGYHUBNG.COM, 2022

Abstract: **The current energy transition differs significantly from previous transitions as it aims to reduce greenhouse gas emissions, principally CO2, and short-lived climate pollutants, dominated by Methane gas, in order to arrest the rising global temperature that is causing the extreme global warming and weather conditions. These extreme climatic conditions are the cause of the rising sea levels, and extreme weather events like floods, droughts, and brushfires, and of course, debilitating health consequences, food insecurity, human migration from devastated environment to political consequences and civil unrest as witnessed in Nigeria between the cattle herdsmen and the indigenous farmers in the middle belt states of Benue and Plateau. The transition is guided by Articles 2.1 and 4.1 of the Paris Agreement; Article 2.1 targets to keep the global average temperature well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C, while Article 4.1 seeks to attain Net Zero Emissions and Decarbonization in the second half the century. The main pathway to achieving these objectives is shift away from fossil fuel to a cleaner renewable source, such as solar and wind, and this will require innovative technologies that are heavily dependent on solid minerals, and rare earth metals. These materials, like oil and gas in the fossil fuel dominated economy, will eventually become the new global commodity as renewable technologies replace fossil fuel in the energy mix. And to efficiently manage this global trade, there are already discussions on a possible Organization of Minerals Exporting Countries, (OMEC) like Organization of Petroleum Exporting Countries (OPEC). While Nigeria is endowed with vast solid minerals resources and some of these rare earth metals, its strategic solids minerals development plans, unfortunately lag other sub-Saharan African countries to strategically position itself in the coming global market that will be regulated by OMEC when it becomes operational. The paper therefore recommends that the Federal Government in collaboration with States, and other Global Stakeholders, seriously review the current solids minerals development plans to take advantage of the new business that will drive the global renewable energy technologies.**

Keywords: **Energy Transition, Paris Agreement, Greenhouse Gas Emissions, Net Zero Emissions, Decarbonization, Organization of Minerals Exporting Countries.**

1. INTRODUCTION

Energy as we know it, exists in the form of potential or kinetic energy, and in other specific forms such as in thermal, electrical, chemical, nuclear, etc. One major characteristics of energy is its indestructible nature as it can neither be created nor destroyed but can change or be transformed from one form to another, a property that is also known as conservation of energy as the first law of thermodynamics. It can, however, be transferred from one body to another as in heat and work, as thermal energy, and mechanical energy in the case of work done respectively. (Briannica, 2020). Energy also has the characteristics of being transformed one form to another propelled mostly by the desire for more secured energy sources, changing needs and consumption pattern, technological innovation, geopolitical dynamics and environmental implications, demand, and supply dynamics, and of course government policy directions. (World Economic Forum Insight Report, 2018). According to the United Nation's ECE Energy Series No 67 of 2020, energy has potentials to end poverty, ensure healthy lives, and raise the living standards within the society. The human muscles and biomass were the early known forms of energy, complemented with the beast of burdens such as oxen and horses and camels used for transportation and to drive ploughs or to turn millstones (Mason, 2020). As human needs increases, other uses of energy such as the windmills were invented to help the sailing of boats through long distant trade routes, and river dams created out of water sources to provide mechanical fluid power. (Mason (2020). Energy is broadly classified as either renewable or non-renewable depending on the capacity to regenerate or replenish their sources. Technically, all forms of energy sources originate from the sun besides that from nuclear energy, geothermal energy, and tidal power. Solar energy is the source of all bioenergy from biomass on the surface of the earth, and by extension also the origin of fossil fuels, which is formed through the process of millions of years of photosynthesis under the action of burial, heat and temperature in the earth surface. It is also responsible for the world's winds; it evaporates the water which is responsible for rain; waves and ocean thermal power are both a result of insolation. (Bhatia, 2014).

The use of either form of energy is also based on the desired for better energy quality, measured in the form of energy density, storability, intermittently, transportability, availability, scalability, environmental externalities, and energy return on energy invested minus net energy. (Euanmearns, 2018). It follows then that either of these energy sources, renewable or non-renewables, can become the alternative source at any point in the energy transition. Renewable energy sources are derived mainly from self-regenerative natural sources while non-renewable, though also exist in nature, are not self-replenishing in nature. They are depleting sources and include mainly fossil fuel which consist of petroleum crude oil, gas and coal. Fossil fuels originate from organic remains of plants and animals or fossils, buried several millions of years, which are acted upon by pressure and temperature in the presence of microbes. On the other hand, renewable energy sources are solar, geothermal, wind, biomass, bioenergy, and hydropower energy. However, nuclear energy can either be classified as non-renewable or renewable energy source depending on the argument. (IEA, 2021). Besides these broad classifications, energy can also be described as being Green, Clean, or Sustainable: Green energy sources emit near zero greenhouse gases, radiation, or chemical contaminants, and only exerts localized impacts on the environment, as they rarely threaten plant or animal species with habitat loss, population reduction, or extinction. Clean energy on the other hand is energy that does not pollute the environment nor increases the amount of greenhouse gases that may contribute to climate change. It only emits negligible amounts of carbon dioxide, radiation, or chemical contaminants, and therefore have minimal to zero carbon and hence impact on the environment. This is the goal for the current energy transition – from dirty and hazardous fossil fuel to cleaner energy sources, such as solar and wind and nuclear power. There is however a very thin line between green energy and clean energy – clean energy is a degree higher than green energy as it literally does not produce greenhouse gas and thus have almost no negative consequences on the environment. (Shipley Energy).

Sustainable energy describes energy sources that not only meet present economic and social needs, but also guarantees the energy requirements of future generations. According to Kukreja (2021), an energy source must have three basic qualities to be described as sustainable and these are (i) it must be naturally replenishable; (ii) ability to improve its energy efficiency through technology, and (iii) must be available in the long term**.** Sustainable energy sources must also meet **e**conomic, political, social, and environmental considerations, which means that, it must be economically viable, politically supported, socially equitable, and environmentally acceptable. Owen and Garniati (2016) thus defined sustainable energy as any economically viable energy resource (not only electricity) that is not, in its lifecycle, a net contributor to climate change and does not have a substantially negative environmental or social impact (actual or potential). Sustainable energy thus requires a balanced composition between energy security, economic development, and environmental protection. Sustainable energy is also self-renewing such as solar and wind, across many generations. Tidal energy and geothermal heat energy can also be classified as sustainable since the interactions of the moon and the earth will always produce tides, and the mantle of the earth will always give off heat that we can access in regions of volcanic and tectonic activity

2. ENERGY TRANSITION

Energy transition according to International Renewable Energy Agency (IRENA) is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. However, Sovacool ,2017, defined energy transition as 'a particularly significant set of changes to the patterns of energy use in a society, potentially affecting resources, carriers, converters, and services'.

In this definition lies the idea that energy transition refers to the time between the first introduction of a new source of primary energy or prime mover, to the time when it captures significant or controlling share in the energy mix. This elapsed time according to Sovacool (2017) could either be protracted or quick as held by two varying schools of thoughts.

One group viewed energy transition as an inclusive system that involves not only the national sources of energy supply and their compositional changes, but also viewed energy transitions as involving different things such as the use of fuels, services, and end-use devices that have occurred quite quickly, within a few years. They cited examples such as the adoption of cookstoves, air conditioners, and flex-fuel vehicles (FFVs) at micro levels, and the almost complete transitions to oil in Kuwait, natural gas in the Netherlands, and nuclear power in France that took only a decade as instances of quick energy transition. The second group however, holds that sustainable energy transition generally takes much longer time, far beyond a decade, as to them, energy transitions are prolonged affairs that take decades to accomplish, and the greater the scale of prevailing uses and conversions, the longer the substitutions will take. They viewed that fast transition only occurs as anomalies and mostly in countries with small populations or under unique circumstances that can hardly be replicated elsewhere. The first energy transition from wood to coal occurred around 1600s in Europe due to scarcity of wood to meet the increasing energy demand with coal becoming the dominant enery source in the 1780s. The use of coal soon expanded with the invention of the first coal fired power plant in the world by the French in 1875. (Zou et al 2016). In the United States, though wood was being used side by side with coal, the demand for coal across the country quadrupled between 1880 and 1918 as large amounts of coal were needed in the production of iron and steel as well as in the railroad industry. (NDSU).

Coal soon began to pose environmental challenges at the onset of the 20th century, a condition that gradually paved way for a more qualitative energy source – petroleum in oil and gas. Petroleum was found to be more flexible and adaptable than coal, as kerosene that was refined from crude became more reliable and relatively inexpensive compared to "coal-oils" and whale oil for fueling lamps. Naturally, with these better qualities, and with innovative technologies in the 20th century, the second energy transition occurred with petroleum crude oil taking over from coal as the preferred fuel to power the global economy. Oil also became a strategic energy source and critical military asset in its role during World War 1 in powering ships, trucks and tanks, and military airplanes. (EKT Interactive, 2020, Oil 101). Ague and Oristaglio (2017), added that petroleum product actually became prominent as alternative fuel during World War I due to the invention and use of more advanced war fares; for instance, the British as at World War I in 1914 had only 800 military motor vehicles, which skyrocketed to 56,000 trucks and 36,000 cars by the end of the war after only four years. Just as for coal, the first member of the fossil fuel family, that initiated and powered the industrial revolution, petroleum products, mostly crude oil and gas in combination with coal, began to create severe climatic and environmental problems globally, with very devastating consequences. With more than 70% of the total global energy mix, fossil fuel – coal, oil and gas soon became the world's enemy to sustainable development, causing an increasing call for their replacement to much cleaner energy sources in the family of the renewables, solar, wind, and hydrogen fuels. This is the third energy transition and the current topic under discussions and investigation in this work. (Rodrigue, 2020)

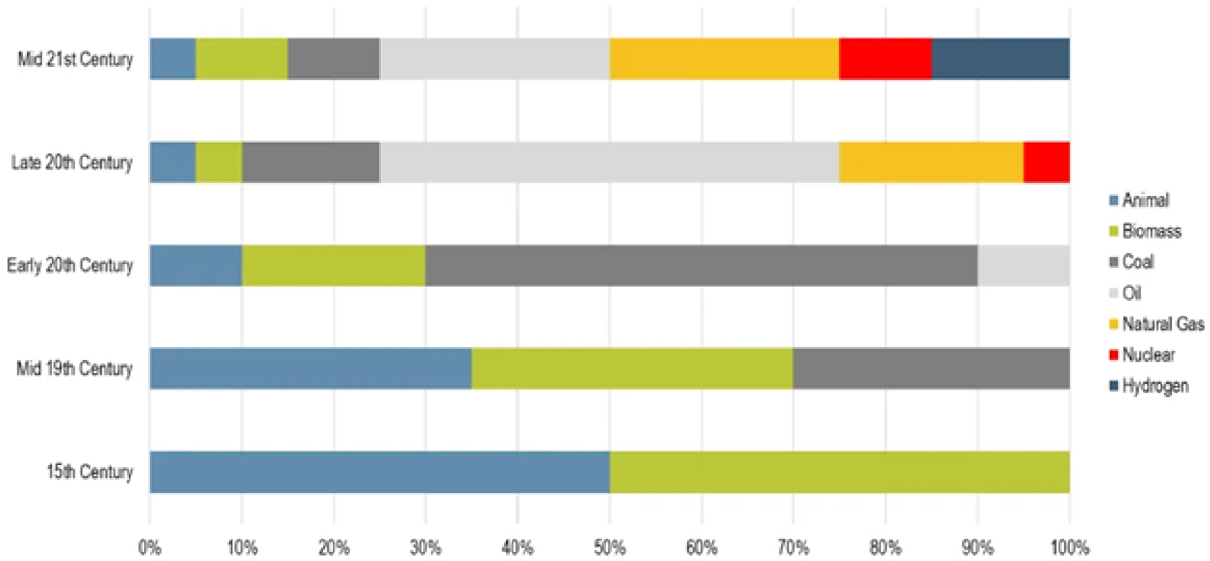


Figure 1: Historical Evolution and Use of Various Energy Sources. Sources: Rodrigue 2020.

3. CURRENT ENERGY TRANSITION

The current energy transition is driven primarily to arrest the rising global temperature, which has resulted to extreme global warming and weather conditions due mainly to high carbon and methane and other greenhouse gas (GHG) emissions into the atmosphere. The transition to renewables is limit the global average temperature within $1.5^{O}C$ by the end of the century as agreed at the 2015 Paris Climate Summit (or COP21). The gases, five in number that are responsible for total global warming are:

1. Carbon dioxide (CO2): a by-product of fossil fuel, deforestation and production of cement and other materials contributes about 52% of all global warming. Technically, about 80% of the CO2 emissions remains active for about 200 years while the balance 20% can take up to 30,000 years before its impact disappears.

2. Methane is a Shortlived Climate Pollutant (SLCP) that only remains effective for about 12 years in the atmosphere. It is produced from multiple sources such as livestock production, agriculture, sewage treatment, natural gas and oil production and consumption, coal mining, and is also given off from wastes. Though methane contributes only 15% of global warming, it is about 84 times more potent than Carbon Dioxide in the first two decades in the atmosphere.

3. Halogenated compounds such as CFCs, HCFCs, HFCs, PFCs, SF_6 and NF_3 contribute only 11 % of global warming. These are chemical products from diverse sources such as refrigeration, air conditioning, electrical and electronic equipment, medicine, metallurgy, etc., These compounds can last from a few months to tens of thousands of years in the atmosphere depending on its constituent compound. The CFCs, HCFCs, HFCs, and PFCs have been banned in much of the world because they have heat-trapping potential thousands of times greater than CO2

4. Tropospheric ozone are gases produced from reaction between carbon monoxide (CO), nitrogen dioxide (NO_2) and VOCs (Volatile Organic Compounds), during the burning of fossil fuels. They contribute about 11% of global warming, and only last for a few months in the atmosphere.

5. Finally, nitrous oxide, a product from the use of fertilizers, fuel use, chemical production, and sewage treatment, contributes around 11% to the global warming, can last for about 114 years in the atmosphere. Nitrous oxide is 264 times more powerful than CO2. (Acciona, 2019).

Lindsey and Dahlman (2020), remarked that the current rise in global temperature above the pre-industrial period of 1880-1900 is due to accumulated heat in the atmosphere, and considering the size and tremendous heat capacity of the ocean, this rise is very significant. It shows that the heat absorptive capacity of the ocean has been impacted seriously. This is what is now driving regional and seasonal temperature extremes, reducing snow cover and sea ice, intensifying heavy rainfall, and changing habitat ranges for plants and animals. Figure 2 is a chart of historical global average anomaly from 1870 to 2020, showing clear steep temperature rise from 1940,

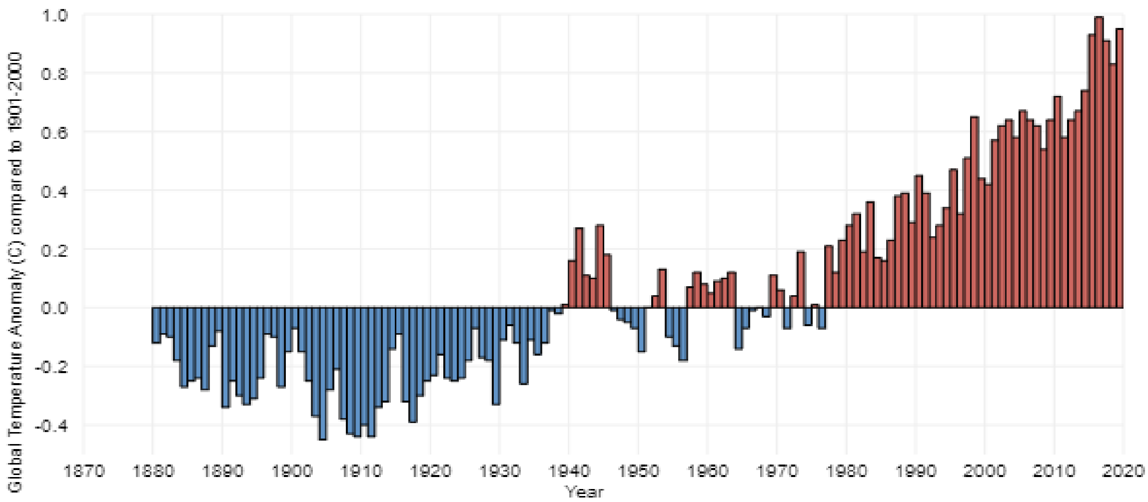


Figure 2: History of global surface temperature since 1880; Source: Lindsey and Dahlman (2020)

Figure 3 shows a chart indicating number of extreme weather events and associated costs from 1990 to 2016.

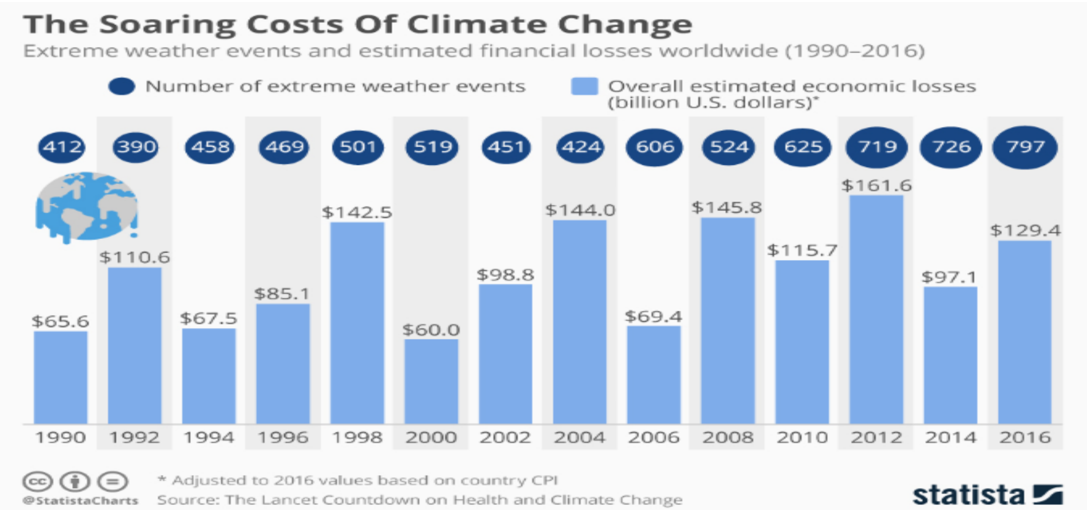


Figure 3: The Souring Costs of Climatic Change: Source: McCarthy, 2017

It is ironical that fossil fuel, that powered the global industrialization and economic growth and development has become its enemy due to the harsh environmental problems associated with its use. This has resulted in the current push for accelerated energy transition to arrest the global devastation caused by the greenhouse gas emissions. The transition is therefore to move away from fossil fuel or non-renewable energy sources to much cleaner renewable energy sources. According to the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change, 25% of C02 emissions come from electricity and heat production, while a further 24% come from agriculture, forestry, and other land use. Industry accounts for 21%, and transportation 14%, and a whopping 60% of global greenhouse gas emissions are from fossil fuels, through the emission of greenhouse gas into the atmosphere that is slowly causing the global temperature to rise above pre-industrial levels. This has caused and is causing devastating effects on nature and humans such as rising sea levels, and extreme weather events like floods, droughts, and brushfires, and of course, debilitating health consequences, food insecurity, human migration from devastated environment to political consequences and civil unrest as witnessed in Nigeria between the cattle herdsmen and the indigenous farmers in the middle belt states of Benue and Plateau. It was in its attempt to arrest the deterioration that led the Intergovernmental Panel on Climate Change (IPCC) of the United Nations, to issue stern warnings that global warming from pre-industrial levels must not exceed 1.5°C to avoid irreparable damage to the planet. This further led to the coming together of 196 countries in 2015 to pledge to work together to slow global warming by cutting emissions and other steps under a collective Paris Agreement, the world's first comprehensive climate change agreement. The main goal of the Paris Agreement as stated in Article 2.1 a is to keep the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C, while Article 4.1 emphasizes on attaining Net Zero Emissions and Decarbonization in the second half the century.

According to some recent scientific studies known as the "extreme event attribution, that has published more than 350 peer-reviewed scientific studies on extreme weather conditions, the number of extreme events have grown substantially over the past 10-15 years, and that, about 92% of recorded extreme heat around the globe were caused by climatic change. The report cited that climatic change made the heat waves intense that let to about 506 of the 735 fatalities in Paris during the 2003 European heatwave. (Carbon Brief, 2021). The Yale Environment 360, published at the Yale School of the Environment in their October 2020 edition attributed this rapid change in weather conditions in the past 20 years largely to the rising global temperatures. The Report recorded about 7,348 major natural disasters around the world, killing 1.23 million people and resulting in $2.97 trillion in global economic losses from 2000 to 2019. The figures when compared with data from 1980 to 1999 indicated only 4,212 natural disasters, 1.19 million deaths, and causing $1.63 trillion in economic losses. Climate-related disasters also rose by 83 percent from the 1980-1999 level of 3,656 events to 6,681 during 2000-2019. Major floods have more than doubled, the number of severe storms has risen 40 percent, and there have been major increases in droughts, wildfires, and heatwaves.

Besides the extreme weather conditions from global warming, the World Health Organization (WHO) also reported additional extremity from air pollution from fossil fuel that kills about 570,000 children under the age of 5 every year, far more than malaria and unsafe drinking water. This figure is part of the estimated 7 million premature deaths linked to air pollution amongst children, elders, the economically poor and even the unborn according to WHO. The WHO also reported that millions of pregnant women deliver premature babies due to air pollutions, with most of these children growing up with lifelong respiratory conditions such as asthma or reduced lung capacity or brain impacts. Air pollution also cause cognitive impairment mental health problems, such as anxiety and depression, breast cancer, autism, appendicitis, and the risk of suicide. (Global Catholic Climate Movement, 2017)

4. LOW CARBON TRANSITION AND NET ZERO EMISSION

Energy transitions are basically a shift away from the present production and consumption patterns using different technologies and sources, and so, a low-carbon energy transition is a conscious shift from high-carbon energy sources such as oil, gas and coal to low-carbon and zero-carbon energy sources such as renewables. Achieving this global shift to low carbon energy sources is seeking to comply with Article 2.1 of the Paris Agreement with a main goal keeping the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C, while Article 4.1 emphasizes on attaining Net Zero Emissions and Decarbonization in the second half the century. However, the recent IPCC report of August 9, 2021 has resonated how critical the global climatic situation has become, which is a clear testimony of the impact of global rising temperatures and the consequences in all the regions of the world. The report showed that, it is almost too late to stop the rising global temperature not to exceed the 1.5^{o}C beyond the pre-industrial level, and therefore calls for immediate, rapid and large-scale reductions in greenhouse gas emissions. This report has created a sense of urgency among citizens, companies and politicians, as record heat, biodiversity loss, extreme weather and ice melting all point to the same conclusion: humanity is losing the fight against global warming. Scientific models have shown that emissions must fall between 25% and 50% through 2030 to limit warming to levels outlined in the Paris accord—below 2º Celsius above pre-industrial levels, or preferably 1.5°C. Emission levels fell a record 7% in 2020 due to coronavirus lockdowns. (Lombrana, 2021). The current transition is therefore to reduce as quickly as possible the quantum of GHG emissions into the atmosphere to arrest the imminent climatic apocalypse, and this would require a deliberate pathway that will achieve the low carbon transition and net zero emissions while also maturing renewables sources and making them readily available and adaptable. The pathway will also include carbon capture and storage technologies and other GHG leakages such as methane leaks into full gear. While the term "energy transition" implies a shift away from fossil fuels, the term "low carbon transition" is intended to suggest a focus on the overall lowering of GHG emissions from the energy sector independent of fuel or technology. On the other, "net zero emissions" or "Paris Agreement compliant" are rather too specific and exclude a wide range of industry and government actions that are moving in the direction of a low carbon transition, although not yet at a scale or intensity to reach net zero or the Paris Agreement's 1.5 degree scenario. (Johnson, 2020).

Technically, Net Zero Emissions means not adding new emissions to the atmosphere, while existing emission sources will be balanced by absorbing an equivalent amount from the atmosphere. The United Nations has set a Net Zero Target for 2050 and have been working with governments and organizations to make pragmatic commitments to achieve carbon neutrality, or "net zero" emissions within the next few decades. Though a huge task that requires immediate ambitious actions, it also requires that countries demonstrate how they will achieve these targets as submitted in their Nationally Determined Contributions, NDCs.(UN, 2020). In achieving the Net Zero Emissions, the focus is to eliminate or reduce these greenhouse gases; carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6) and specified kinds of hydro fluorocarbons and perfluorocarbons. These emissions are generally measured as kilotonnes of carbon dioxide equivalence (CO_2-e), this is because carbon dioxide has been set as having a global warming potential of one. This means that one tonne of methane released into the atmosphere will cause the same amount of global warming as 25 tonnes of carbon dioxide, therefore the one tonne of methane is expressed as 25 tonnes of carbon dioxide equivalence, or 25 t CO_2-e. (Clean Energy Regulator, 2021)

5. NIGERIA'S DIVESTMENT INTO SOLID MINERALS IN THE ENERGY TRANSITION

This section presents the prospects of mineral rich countries to take advantage of the new trade in energy minerals that will provide the feedstock for renewable technologies in the energy transition. The section discusses the demand and supply side of these minerals and rare earth metals in the new mineral energy materials (MEM) trade and closes with the opportunities for mineral rich countries, like Nigeria, to diversity their economies to take advantage of a potential new trade that can drive the global economy the way hydrocarbons did during fossil fuel dominated energy system.

5.1 Demand Side of Minerals and Rare Earth Metals in the Energy Transition

The current energy transition to renewables brings with it new technologies that are different from the energy systems of hydrocarbon sources, as they are mostly dependent on solid minerals, and rare earth metals. For instance building a typical electric car will take six times more mineral inputs than a conventional internal combustion engine (ICE) car, while an onshore wind plant would require nine times more mineral resources than its fossil-fuel gas-fired power plant, as shown in figure 69. Generally, the minerals needed differ with the renewable technology, and so their demand will also depend on the demand of the type of renewable technology. Energy storage systems such as battery and their capacity and performance require Lithium, nickel, cobalt, manganese and graphite, while wind turbines and electric vehicles that operate with permanent magnets require rare earth elements. Copper and aluminum are the feedstock for electricity networks with copper being a cornerstone for all electricity-related technologies. The transition to a clean energy system will cause a huge increase in the demands for these minerals, which, up until the mid-2010s, only contributed a small portion of total demand for most minerals but has now recorded about 50% in demand for a new unit of power generation capacity. The IEA thus projected that, to meet the Paris Agreement goals, it would require a spike in demand for some minerals such as copper and rare earth metals which will rise to over 40%, and that for nickel and cobalt to rise to between 60-70% and nearly 90% for lithium. This is because electric vehicles and battery storage have already displaced consumer electronics to become the largest consumer of lithium and are also expected to beat stainless steel as the largest end user of nickel by 2040.

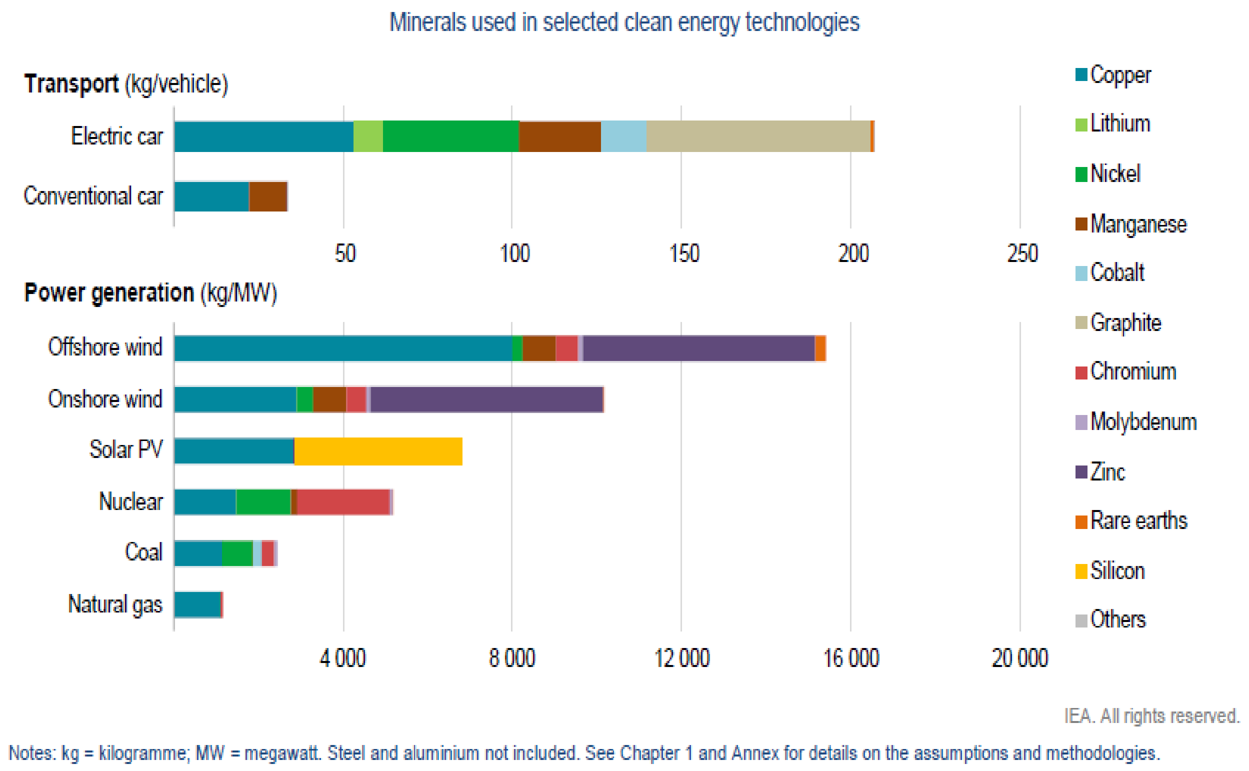


Figure 4: Different types of minerals used in selected clean energy technologies. (IEA, 2021)

Transitioning to a low-carbon energy system is therefore a huge business opportunity for minerals rich countries as the demand for renewables continue to shore up in the decades ahead. For instance, for every 1 megawatt (MW) of capacity of solar PV, about 3,000 solar panels are needed, while each wind turbine for wind power contains about 3.5 tons of metal and each electric vehicle for electric transportation, requires 83 kilograms of copper. These demand prospects suggest promising opportunities for resource-rich countries, which will in turn prompt their governments to making policy and investment actions to channel and support the development of their respective mining industries, in the global energy transition context.

Figure 5 is a World Bank projection of the Annual Mineral Demand Under 2°C Scenario only from Energy Technologies in 2050, compared to 2018 production levels.

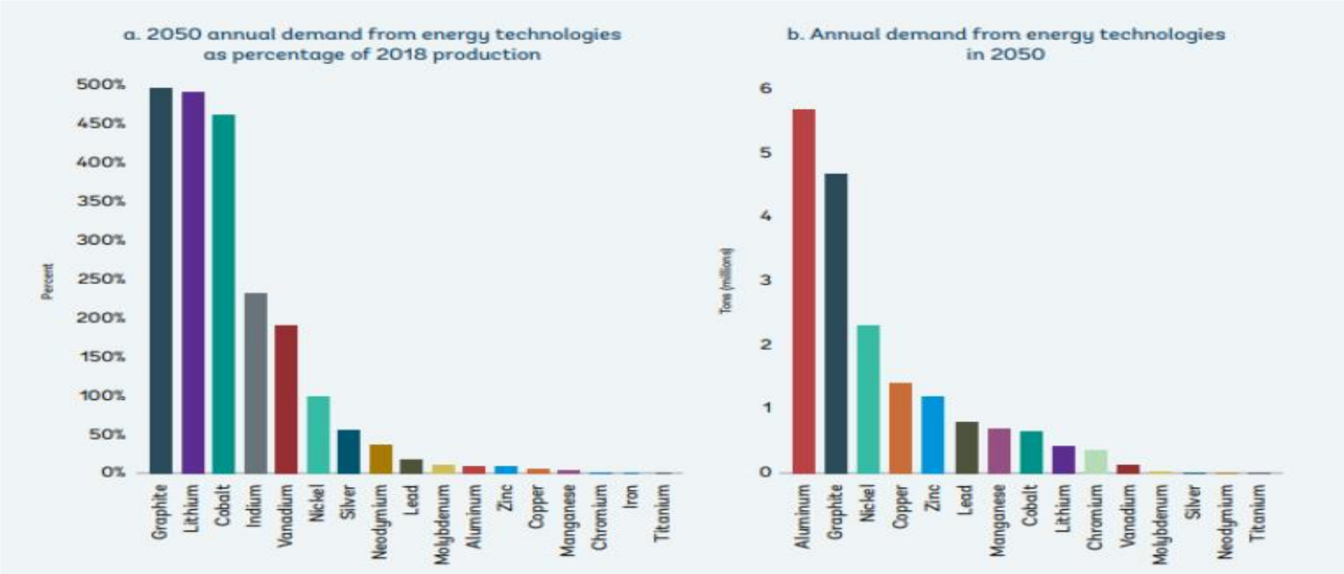


Figure 5: Projected Annual Mineral Demand under 2° Degree Scenario. Source: El Baz, 2020 from World Bank Group

Figure 6 shows the IEA growth projection for some selected minerals in the transition period

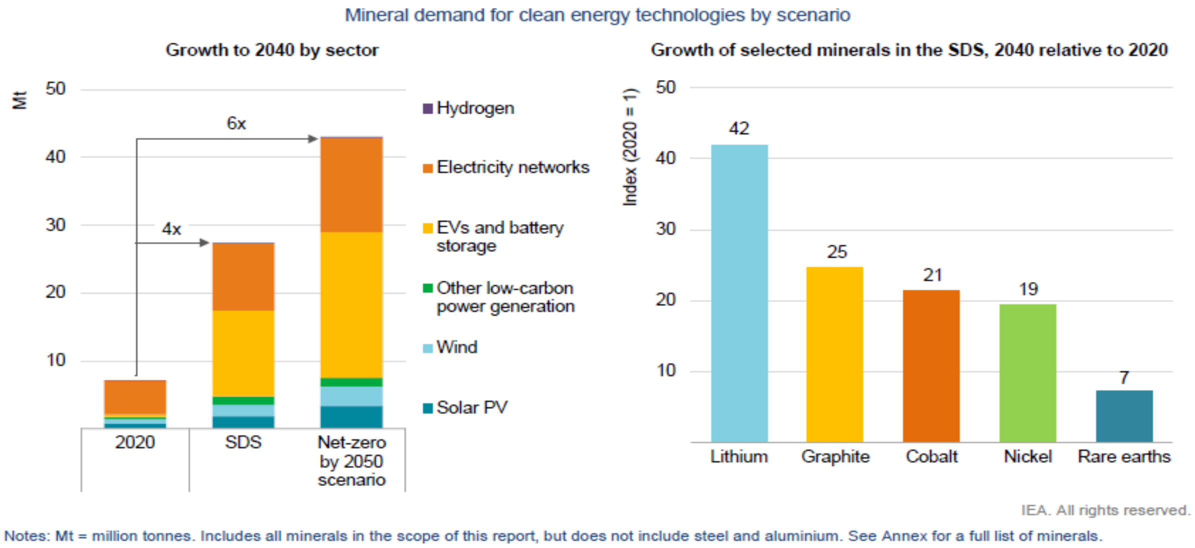


Figure 6: Minerals demand for clean energy technologies by scenario

The critical minerals for the new energy systems driven by renewable technologies based on the World Bank and IEA projections will be lithium, graphite, cobalt, nickel, rare earth metals, aluminum, copper, zinc, lead, manganese, chromium and vanadium. So, depending on how rapidly governments act to reduce emissions, demand for these critical minerals is expected to increase by six times by 2040. The wind sector is expected to take the lead, bolstered by material-intensive offshore wind. Solar PV will follow closely, due to the sheer volume of capacity that is added. The expansion of electricity networks also requires a huge amount of copper and aluminum. Also, the commercial importance of these minerals is also expected to increase owing to an increase in demand and as such regulation is needed to ensure price stability. (Nhede, 2021).

Prior to this noticeable demand due to energy transition, Kesler, 2007 had identified potential increase in global demand of minerals due to rising world population that would come with increase in mineral consumption as the global standard of living increases. According to Kesler, 2007, world demand for minerals will be affected by three general factors—uses for mineral commodities, the level of population that will consume these mineral commodities, and the standard of living that will determine just how much each person consumes. Kesler, 2007 also identified economic cycles, recycling, and other factors that are likely to be second-order controls on overall demand for new minerals, although they will be important locally and for shorter periods.

5.2 Supply Side

While the demand side presents huge prospects for the natural resource-based countries, the major challenge will be on how to meet these demands from the supply side- on the availability and reliability of supply. IEA has in their report, identified some vulnerabilities associated with the supply side especially as demand increases and tend to outpace supply, and these include:

(i) High geographical concentration of production: Unlike hydrocarbon resources that are spread across the globe, minerals and rear earth metals are concentrated in a few countries as shown in figure 7,

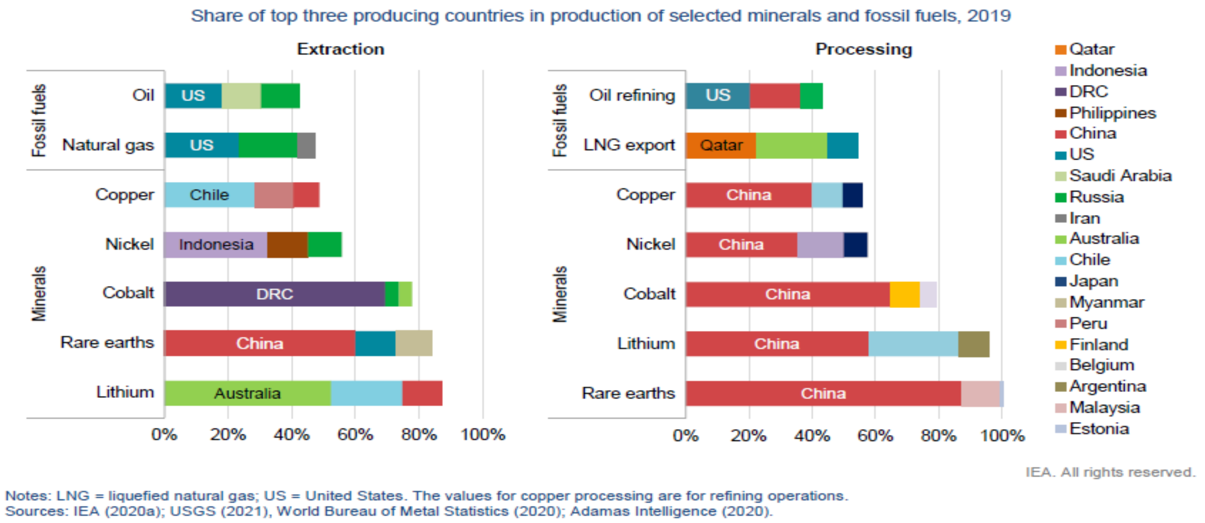


Figure 7: Distribution of energy minerals for renewables across different geographies. Source: IEA, 2021

For instance, the Democratic Republic of the Congo (DRC) and People's Republic of China (China) alone hold about 70% and 60% of global production of cobalt and rare earth elements respectively in 2019. Figure 8 shows the top three producing countries in total production of selected minerals in 2019. The chart shows that Chile is top in copper, while South Africa tops in Platinum. China is top country in rare earth metals and graphite, while Australia is tops in lithium.

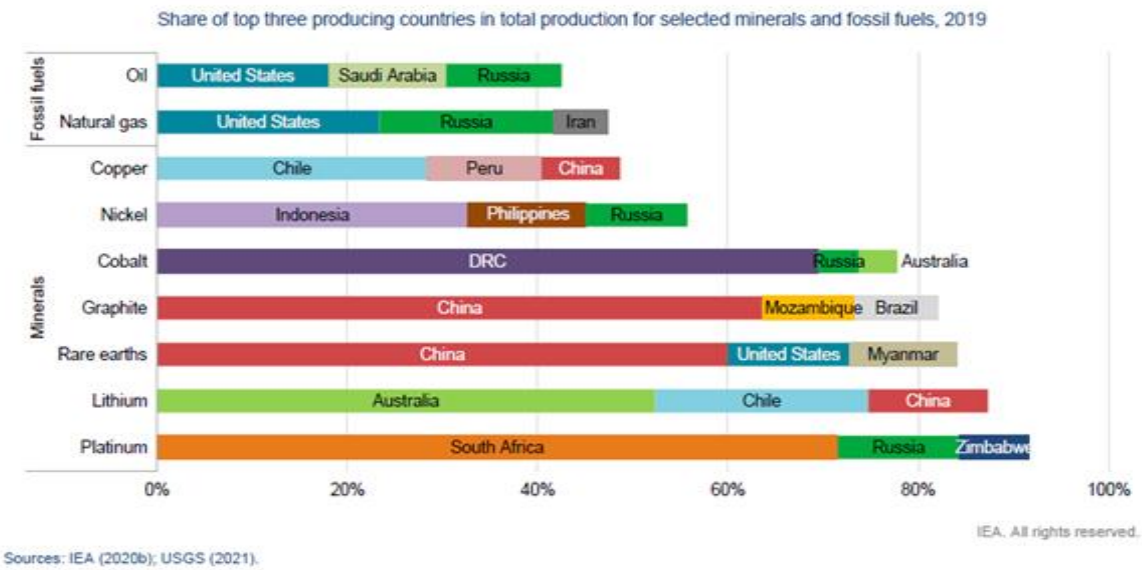


Figure 8: Share of top three producing countries in total production for selected minerals and fossil fuel, 2019.

In terms of processing capacity, as input into renewable technologies, as shown in figure 9, China holds around 35% for nickel, 50-70% for lithium and cobalt, and nearly 90% for rare earth elements, with increasing investments in overseas assets in Australia, Chile, the DRC and Indonesia to consolidate their hold on renewable technologies.

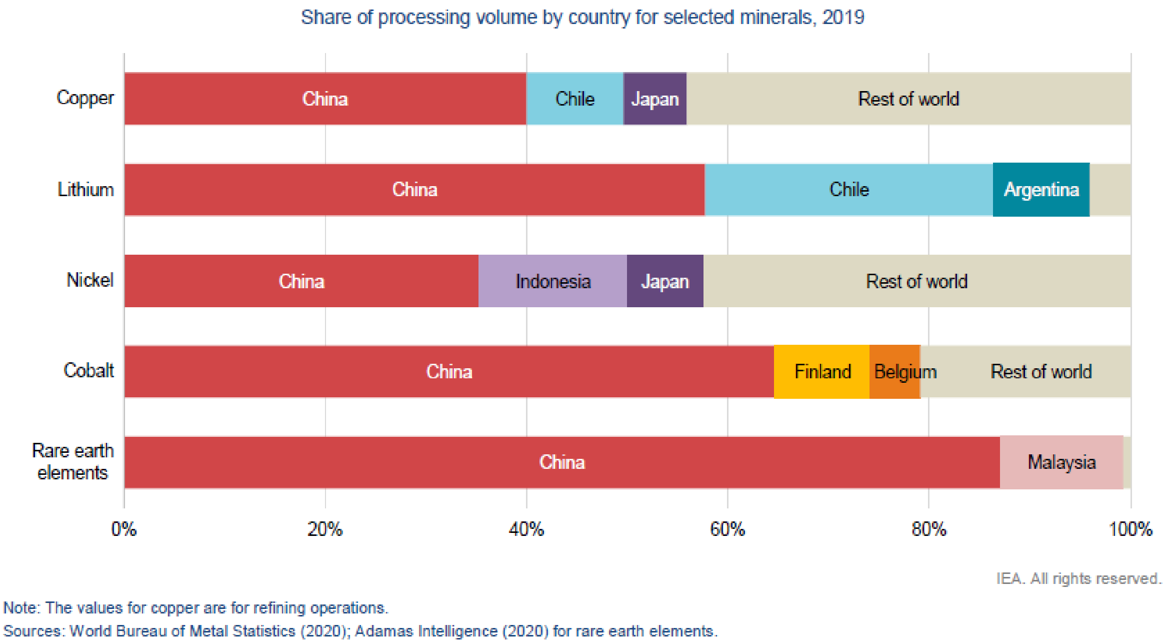


Figure 9: Share of processing capacity by country for selected minerals, 2019. IEA, 2021

This distribution portends a major challenge in the economy of the transition minerals due to the high levels of concentration, compounded by complex supply chains, which will definitely increase the risks that could arise from physical disruption, trade restrictions or other developments in major producing countries.

(ii) Long project development lead times: One other threat in the supply chain of these transition minerals is the rather very long project development time**,** about 16 long years from discovery of that mineral to first production. To successfully transit into renewables, the time is now to intensify their production, and not to wait for deficits to emerge before committing to new projects, which could lead to a prolonged period of market tightness and price volatility.

(iii) Declining resource quality: Another concern is the progressive deteriorating quality of these minerals with time**.** For instance**,** the average copper ore grade in Chile declined by 30% over the past 15 years, which poses additional challenge in extraction, as more energy is required in extracting metal content from lower-grade ores. This will also create an upward push on production costs and increase in greenhouse gas emissions and waste volumes.

(iv) Growing scrutiny of environmental and social performance:

The continuous use of these minerals as demand increase will further cause a rise in environmental and social pressure on companies due to the devastating impacts of the production and processing processes on the environment. It is therefore important that, as part of the transition, mining must adopt sustainable processes to create the needed balance. Already, consumers and investors are pressing hard for companies to source minerals that are sustainably and responsibly produced. (IEA). The mining industry must also adopt green energy technologies to reduce its emissions, as it is also a notoriously energy-intensive and high CO2 emitting industry accounting for approximately 2–11% of total global energy consumption, and 26% of global carbon emissions. It must therefore pursue SDGs 7 (affordable and clean Energy), 12 (sustainable consumption and production) and 13 (action against climate Change), policies to create a climate-smart mining practices, including the integration of renewable energy to power mining operations. (El Baz, 2020).

(v) Higher exposure to climate risks: The climatic problems ravaging the earth as a result of the GHG emissions also affects the mining industry as several major producing regions such as Australia, China, and Africa are exposed to extreme heat or flooding, which pose greater challenges in ensuring reliable and sustainable supplies. Minerals such as copper and lithium are particularly vulnerable to water stress given their high water requirements, and that over 50% of today's lithium and copper production is concentrated in areas with high water stress levels.

One other critical factor that will impact the supply side is the current global mineral reserves, which according to Kesler, 2007, is theoretically adequate to supply world mineral demand up to 2057. However, Kesler, 2007 noted that the estimated global mineral reserves are 20 to almost 1,000 times larger than present annual production, depending on the commodity of interest. This notwithstanding, the commerciality of these reserves strongly depends on the geologic, engineering, economic, environmental, and political constraints that undergo continuous change.

Geologic factors, according to Kesler, 2007, are of first-order importance and can range from new discoveries to changes in mining, beneficiation, smelting, or other treatment processes. Finding new mineral is the most important stimulus to exploration because they provide a reason to explore areas or geologic environments that were considered previously to be without potential. Technically, the process of discoveries of a new mineral ranges from recognition of a new, completely unfamiliar type of deposit, to recognition of possible lateral or depth extensions of known deposits or districts. Also, there are political, economic, and environmental factors that may affect new discoveries, as they can each either encourage or discourage exploration activities. In order therefore to meeting the rising demand for minerals, especially to meet the expected rise in energy metals for the energy transition technology, Kesler, 2007 recommended that aggressive research be conducted by individual countries endowed with mineral resources into the nature of the deposit and the processing method. He also recommended effective geologic mapping and related geochemical and geophysical surveys to compile data on known deposits, prospects, and favorable geologic environments, and finally countries must also conduct subsurface mapping and sampling of their area to properly delineate their mineral deposits.

According to the IEA, extracting and processing the minerals required as raw materials for the renewable technologies will add significantly to the overall cost structures of many technologies, as raw materials alone account for some 50-70% of total battery costs, up from 40-50% five years ago, which will in turn significantly impact of the delivery of these technologies in the transition. IEA further projected that expected supplies from existing mines and projects under construction can only meet half of projected lithium and cobalt requirements and 80% of copper needs by 2030. The renewable industry therefore has a great task to secure adequate material supply, and the reason to begin the search for more diversified supply sources that can meet the demand in the transition. Diversification of supply will be very crucial as resource-and this can be achieved through collaboration between the technology providers and resource endowed governments. The governments would need to reinforce national geological surveys, streamlining permitting procedures to shorten lead times, providing financing support to de-risk projects, and raising public awareness of the contribution that such projects play in the transformation of the energy sector.

This is where Nigeria and other Africa resource endowed countries can take advantage of the supply side challenges and formulate appropriate policies to diversify their economies into transition minerals. (IEA, 2021)

6. NIGERIA'S PARTICIPATION IN TRANSITION MINERAL TRADE

Nigeria like most sub-Saharan African (SSA) countries is endowed with vast non-fuel natural mineral resources most of which are still untapped. According to the US Geological Society ranking, Africa is well endowed with several mineral resources including diamonds, platinum, bauxite, manganese, gold and cobalt among others, which are spread all across the continent from Senegal in the west to Ethiopia in the east, and South Africa in the South. Specifically, diamonds are found throughout the continent while copper is ubiquitous in the Democratic Republic of Congo, Tanzania, South Africa and Namibia. Therefore, besides hydrocarbon resources, the continent can also make significant impact in the energy transition through export of Minerals Energy Materials. And no doubt, this has attracted exploration and mining initiatives by China, including multinational conglomerates on the continent. (Mining Africa, 2021).

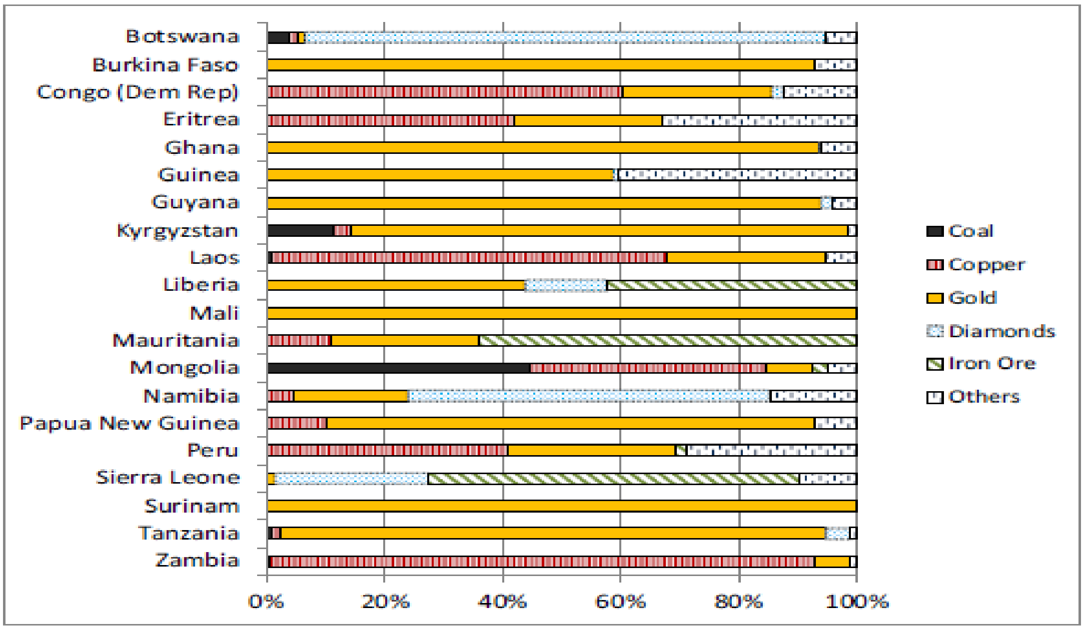
Ericsson and Lof (2019) established the mining contribution index (MCI-Wr) computed based on value of mine production, mineral exports, exploration and mineral rents to measure the contribution of mining to national economies, as shown in table 1. The results showed some African countries as strongly dependent on mining based on the index in 2016, such as the Democratic Republic of Congo (DRC) that is ranked as the country with the largest contribution of mining to its economy. Mineral exports constitute 86% of total exports and the DRC is ranked as the second most important country in relation to mineral export contribution.

Table 1. Mining Contribution Index for selected countries. Source: Ericsson and Lof, 2019

Country	Rank 1996	MCI-Wr score 1996	Rank 2016	MCI-Wr score 2016	Change in rank
Congo, Dem. Rep.	29	72.2	1	93.0	↑
Burkina Faso	64	55.6	2	92.9	↑
Mali	57	59.4	3	91.6	↑
Papua New Guinea	3	89.5	4	91.1	↓
Eritrea	119	24.4	5	90.3	↑
Namibia	11	83.5	6	90.1	↑
Mauritania	9	84.9	7	89.5	↑
Suriname	42	66.5	8	89.3	↑
Peru	8	86.7	9	88.3	↓
Liberia	37	67.6	10	88.2	↑
Botswana	10	83.8	11	88.2	↓
Chile	4	88.6	12	87.8	↓
Zambia	5	87.5	13	87.3	↓
Guyana	2	90.8	14	87.2	↓
Sierra Leone	19	77.2	15	87.1	↑
Mongolia	27	72.8	16	86.0	↑
Australia	6	87.4	17	84.6	↓
Guinea	1	91.7	18	84.3	↓
Tanzania	41	66.9	19	83.4	↑
Kyrgyz Republic	20	77.0	20	83.2	↔

Source: Own calculations

Figure 10. shows the different minerals that were used in the computation of the MCI-Wr



Contribution by commodity to MCI-Wr for Top 20 low- and middle income economies (%) Source: RMG Consulting

Figure 10: Contribution by commodity to MCI-Wr for Top 20 economies

According to the 2016 computation, Nigeria ranked 130 out of the 208 countries, with an insignificant contribution of 0.07% of GDP and only 2% of total export as at 2016. In comparison, Ghana was ranked 21, with 6.08% contribution to GDP and 36% of total export; South Africa was ranked 30, with 4.59% contribution to GDP and 35.2% of total export. (Ericsson and Olof, 2019). The World Bank Group further reported that sub-Saharan Africa has vast resources of non-fuel minerals, which constitute a significant share of national GDP for some countries, and some of these countries are already members of Minerals Exporting Countries. Between 1995-2018, Minerals Energy Materials (MEM) accounted for 23% of SSA total Export compared to 48% of hydrocarbon exports during the same period. Figure 11 shows the trend of both exports, with MEM trending upwards from 1995 to 2018. (Galeazzi et al, 2020).

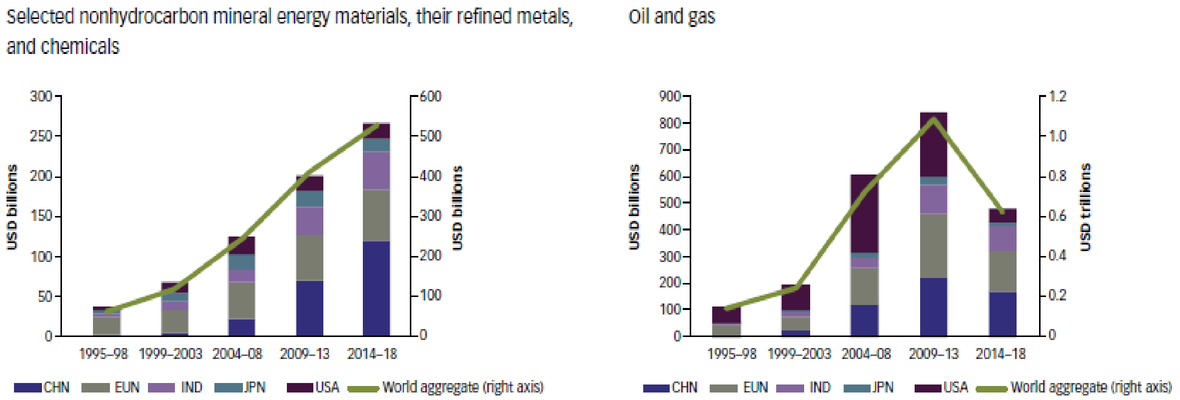


Figure 11. Selected nonhydrocarbon minerals materials, their refined metals, oil and gas and chemicals. Source: Galeazi et al 2021

The mining sector is a critical backbone of the industrialized value chain, being an essential source of input materials for significant sectors, such as construction, automobiles, electronics, shipbuilding, etc. Like oil and gas, Nigeria is well endowed with metallic minerals, but it has not exploited its potential for industrial development due to poor infrastructure for extracting, processing and transporting exploited minerals. The weak value chain in the sector is evident as steel processing operations depend on imported raw materials such as billets, semi-finished products, etc. valued at $618 million in 2018. (Mining Review Africa, 2020).

6.1 Brief on Nigerian Mining Sector

Nigeria is endowed with 44 different types of commercially viable minerals identified in more than 500 locations as shown in the figure 79, spread across different segments of Nigeria and each of the 36 federating states have a fair share of the solid mineral inventory of the Nation. Seven of these minerals have been declared as strategic minerals by the Federal Government due their potentials of making significant contributions to Nigeria's economic development. The seven strategic minerals are coal, bitumen, limestone, iron ore, barites, zinc and gold. The designation of these minerals as strategic, according to the Ministry, stems from their potential to make significant contributions to Nigeria's economic development.

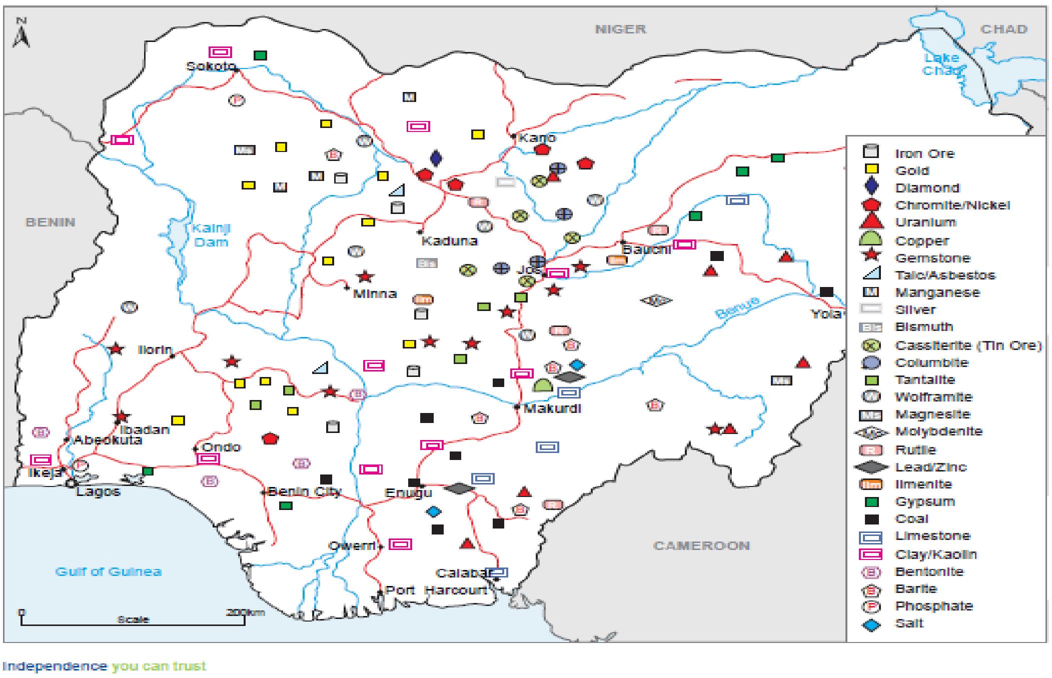


Figure 12: Distribution of solid minerals in Nigeria. Source: Ojo, 2015.

According to the Ministry of Mines and Steel Development, the 40-45 different minerals are categorized into 5 major groups based on usage, or from geological terrains in which they are found, and these are:

(i) **lndustrial minerals** (e.g.barite,kaolin, gypsum, feldspar,limestone)

(ii) **Energy minerals** (e.g. coal, bitumen, lignite, uranium)

(iii) **Metallic ore minerals**{e.g.gold,cassiterites,columbite,lron ore.lead-zinc, copper)

(iv) **Construction minerals** (e.g.granite, gravel,laterite,sand)

(v) **Precious stones** (e.g.sapphire.tourmaline. emmeral, topaz, amethyst.garnet etc.')

In terms of minerals reserves, Nigeria has 568m tonnes of proven reserves of limestone, and potential total reserves of 2.3trn tonnes, yet only 11m tonnes are quarried annually. Limestone is an important ingredient in cement. It also has about 15 million tonnes of Barite, an important ingredient in drilling fluids used by the country's oil and gas companies and is domestically produced at a rate of 20,000 tonnes per year. (Oxford Group, 2017). Some of the minerals have reserves that can compete globally, such as the more than 3bn tonnes of iron ore, being the 12th-largest iron reserves in the world, and the estimated 42bn tonnes of bitumen reserves, which is potentially the second-largest deposit in the world, yet the country imports most of its bitumen for road construction from Venezuela and Canada. This is in addition to the nearly 10m tonnes of lead and zinc reserves across eight states, and about 3bn tonnes of coal, much of which is clean and bituminous with a low sulphur and ash content, which has potential of meeting as much as 30% of the country's power needs. (Oxford Group, 2016). The Country also has a very competitive and robust Mining Regulatory Framework, compared with other Major Mining Countries as shown in table 2

Table 2: Comparison of Nigerian Mining Regulatory Framework with selected countries. Source: Ministry of Mines and Steel Development, 2016.

		Australia	Chile	South Africa	USA	Nigeria
Corporate Income Tax		30%	20%	28%	40%	20-30%
Royalty	Coal	2.75-15%	0-14%	0.5-7%	8-12.5%	3-5%
	Gold	2.5-5%	0-14%	0.5-7%	4-10%	3-5%
	Copper	2.5-5%	0-20%	0.5-7%	4-10%	3-5%
	Iron ore	5.35-7.5%	0-14%	0.5-7%	4-10%	3-5%
Financial Incentives		• EDI encourages shareholder investment in small exploration companies by offering tax credits	• Companies under stability tax agreements charged flat tax rate (4-5%), lower than progressive tax rate paid by others	• CAPEX by mining companies can be fully deducted against tax - E.g. spending on prospecting; mining equipment etc.	• Tax structure permits depletion deduction which can lower federal income tax rate by ~3%	• Tax holiday for an initial period of 3 years from commencement of operations
Custom duty		• 5% import duty for importing mining equipment • Additional import processing charge	• 6% import duty for importing mining equipment	• 0% import duty rate for importing mining equipment	• 0% import duty rate for importing mining equipment	• Exemption from custom and import duties on mining equipment*
Lease duration		21 years	Indefinite	30 years	20 years	25 years
Ownership requirement		• Acquisition of 15% or more interest in any Australian mining co • Acquisition of interest in an operational mine	• Non-discrimination between domestic and foreign-owned entities	• 26% stake by a local directly or via holding Co.	• N/A	• Foreign company to incorporate local subsidiary (with exceptions)
Mining production index (2014)		131.2	111	98	133.9	84.1
Policy perception index (2013/14)		76.61/70.47**	70.86/72.23	39.78/44.47	71.8/69.08**	30.54/10.63

Notes: EDI = Exploration Development Incentive, EPBS = Enhanced Project By-law Scheme; higher mining production index indicates better performance. Policy perception index is the outcome of surveys of investors working in the market. Nigeria's scores reflect the absence of global mining majors and juniors
Source: Fraser institute annual- Survey of Mining Companies, 2014; Literature Search

Despite this massive mineral wealth, and the favourable regulatory framework, the Nigerian mining industry is vastly underdeveloped and only accounts for only 0.3% of GDP in 2015. The country earned as much as 50% of GDP from mining in the 1970s mining but was neglected due to resource curse from oil and gas revenues. sources. (Oxford Business Group, 2017). The Ministry of Mines and Steel Development attributed this poor development of the sector to 5 major causes, and these are: (i) lack of accurate geoscience information and data and the inefficient mode of disseminating this information to investors, (ii) lack of major players in the sector, as most of the miners are artisanal and small-scale miners, who are most times doing this illegally. There is also lack of major infrastructure and logistics to move products from the mining site to the processing site. Another major challenge is the refining and processing capacity because of the limited grid power in the country, as the refining and processing industry would require collectively upward of 100,000 MW of electricity, which is far more than the generation capacity in the country. The industry also lacks efficient trading mechanism such as a licensed mineral buying centre and a formal and effective commodity exchange centre. (iii) managing all the stakeholders in the sectors from government to host communities, donors and international agencies and professional associations, (iv) the sector also suffers from poorly understood institutional framework by the stakeholders and the participants, and lack of an effective enforcement structure to curtail deterrents in the sector. (v) lack of an enabling environment for the minor sector. (Ministry of Mines and Steel Development, 2016). Additional challenges as noted by Azobu and Jaiyeola, 2019 include existence of multiple regulations which requires additional costs and requirements to adhere to these multiple regulations. An instance is the land use act and the mining act 2007, which requires that the title to the land resides with the State Governments, and the mineral resources on the land or underneath it resides with the Federal Government.

The Federal Government, in its strategy to commercialize its vast mineral resources, thus developed the RoadMap in 2016 structured into three phases:

Phase-1: To stabilize the sector and to rebuild market confidence – 2016-2018; Please 2: Establish Nigeria as a competitive African mining and mineral processing center – 2016-2020; Phase 3: Selectively compete in the global market for refined metals and minerals, in addition to select ore exports – 2018-2030; The expectation of the Road Map is to generate a total revenue of $27 billion from the mining sector by 2025 as shown in the figure 13

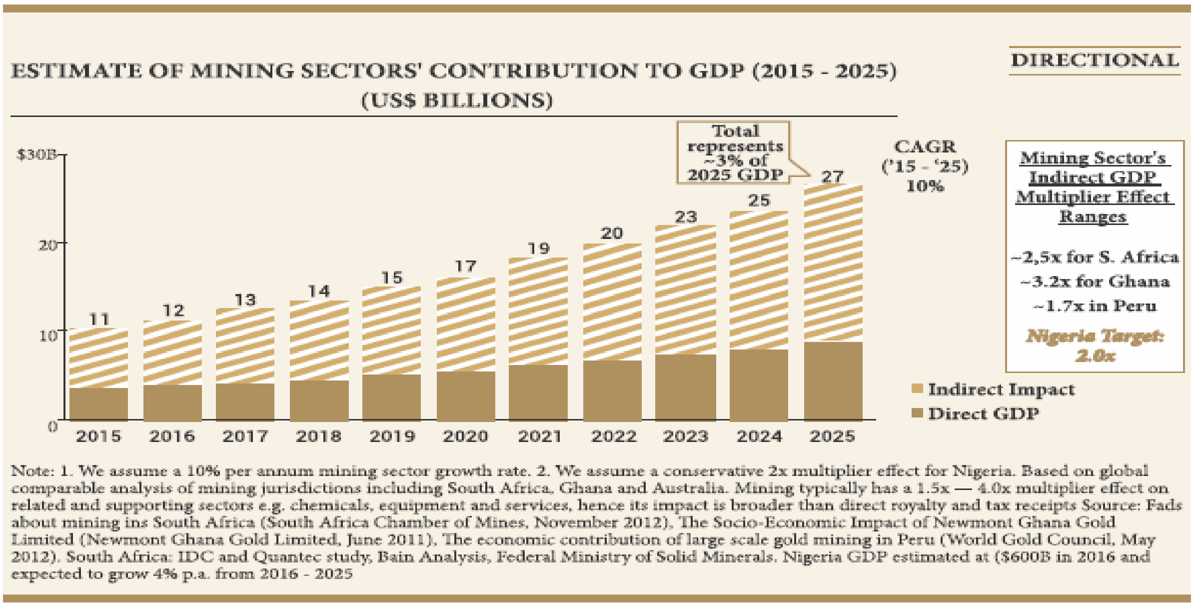


Figure 13: Estimate of Mining Sectors' contribution to GDP – 2015-2025 (US$, Billions). Source: (Treadgold, 2021).

The road map is predicated on promoting the 7 strategic minerals, iron ore, gold, barite, limestone, coal, bitumen, and lead/zinc. The strategy is to initially supply the domestic Nigerian and the African market for industrialization and infrastructure development. The strategy however hopes to explore international export market as the global market grows, which is already active due to demand for renewables technologies. (Treadgold, 2021). The 2016 RoadMap further projected that Nigerian mining industry will by 2025 contribute around 3% of GDP, with over $5bn in new investments in the intervening years. The strategy is to reinforce many of the principles established under previous legislation, such as the possibility of 100% foreign ownership of projects. One other major change is the establishment of an independent "super-regulatory agency" that would merge the Mining Cadastre Office, the Mines Inspectorate Department and the Mines Environmental Compliance Department. The new agency would be separate from ministries, in a role not unlike the Nigerian Communications Commission, which oversees the telecoms industry. (Oxford Business Group, 2019). The Federal Government is coming to terms that it must develop its vast mineral sources to diversify its economy from oil and gas dependency and have therefore continued to review the policies and fiscal frameworks guiding the mining sector from time to time. As part of the efforts, the government released new mining regulations in 2011 to establish greater accountability in the sector, reducing the discretionary awarding of titles. This has helped mining exploration firms to obtain a non-exclusive reconnaissance permit for a period of one year for non-drilling prospecting activities and have an exploration license for areas no greater than 200 sq km to conduct drilling and other activities for a period of three years, with two opportunities to extend the permit for two more years. The mining companies can also apply for a mining lease for a period of up to 25 years, with the option to renew for another 25 years, with a minimum work programme regulated by the Mines Inspectorate Department of the Ministry of Mines and Steel Development. (Oxford Business Group, 2019).

The Government has also reconstituted the Board of the Solid Minerals Development Fund (SMDF) in 2017 to fund key sector initiatives, and in collaboration with the Bank of Industry (BoI), launched a N5Billion fund to provide single digit interest loans for mining projects. They also established the national council of mining and mineral resources development, and the setting up of the Nigerian Institute of Mining and Geo-sciences, Jos in Nov 2018 for training of manpower for the sector and research. License has also been issued for the first gold refining in 2018 under the National Gold development efforts, and strategic focus in Bitumen and Steel to harness the full potential of these resource for economic development. There have also been efforts to curb Illegal Mining through the provision of surveillance vehicles for the Mines Inspectors across the Country and increased inter-agency co-operation. Works are also on to revamp the moribund Mineral Buying Centers across the country, and finally, there has also been visible increase in the participation of State Governments in the sector following better collaboration between the Federal Government and the States. This has also led to the States also earning the 13% derivation for national solid minerals as incentive for developing the sector and monitoring revenue collection. (Azobu and Jaiyeola 2019). These reforms notwithstanding, Nigeria has failed to attract large-scale foreign investment, while neighbouring Côte d'Ivoire became an attractive site for exploration firms – such as those listed on Canadian, Australian and UK stock markets – to search for precious and base metals. The country, sadly has consistently been among the lowest-scoring African countries in Canadian think tank the Fraser Institute's "Annual Survey of Mining Companies", which reviews global mining jurisdictions and their attractiveness. In recent years it has failed to collect sufficient data to provide an accurate score for Nigeria. (Oxford Business Group, 2019). Regardless, the mining sector recorded some modest growth, though below the projections in the 2016 Roadmap. The sector recorded an increase in real GDP from ₦87.6 Billion ($0.287billion) in 2016 to ₦87.7 Billion ($0.288 billion) in 2017 and a significant leap in 2018 to ₦96.6 Billion ($0.315 billion). These are a far cry from the Roadmap projections of $13 billion and $14 billion for 2017 and 2018 respectively. The solid mineral sector only contributed 0.57% of the total export in 2017. However, in absolute terms, the trend analysis shows that total solid minerals export stood at ₦1.94 billion in 2015, and witnessed a geometric leap to ₦11.16 billion in 2016 and upto ₦77.23 billion in 2017. Which is an indication of growth, though still very much marginal when compared to the performance of other sub-Sahara African countries. (Dairo, 2020). The growth in the sector despite the widespread economic impacts of the pandemic, jumped from its 2019 contribution of N369.00 billion; $1.2 billion, to N656.18 billion ($1.72 billion) in 2020. The trend of the Sector's contribution to GDP in the last three years is shown in the figure 14 below

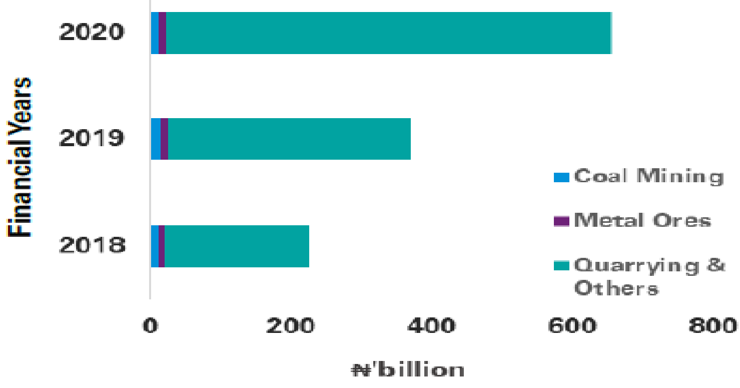


Figure 14: The Contribution of Mining Sector to GDP, 2018-2020; Source: KMPG, 2021

The performance shows that the Sector's contribution to the Nation's GDP is mainly attributable to quarrying activities which comprise sand, gravel and crushed rocks for instance Limestone (for producing cement), and not from the full basket of its strategic minerals. A further indication of a missing link between its Roadmap and the realities. The high performance from the quarrying activities is also attributable to an increase in construction activities across the country as well as increase in the export of clinkers manufactured from Limestone. In addition to this, the CBN, also its first locally sourced gold bar from local miners under the Presidential Artisanal Gold Mining Development Initiative (PAGMDI) in July 2020. The Gold bar, which weighed 12.5kg was purchased for N268 million. The Gold purchased by the CBN under this programme is meant to build Nigeria's Gold reserve and to manage the perennial local foreign exchange volatility. The Federal Government also launched the first gold refining company, Dukia Gold & Precious Metals Refining Company Limited (DGPMP), and Gold buying scheme in June 2020. The DGPMP plans to acquire Gold locally and process the Gold to meet the highest international standards, thereby enabling fair pricing and value for precious metals sourced and produced in Nigeria. (KMPG, 2021)

While there are visible improvements from the impact of the 2016 RoadMap, though still very insignificant compared to the projections for each of these years, the RoadMap obviously did not envisage the disruptions that will come with energy transition, where the demand for minerals for the renewable technologies will surge. As a consequence, there was no consideration in the Roadmap on the critical minerals, and rare earth metals (lithium, graphite, cobalt, nickel, rare earth metals, aluminum, copper, zinc, lead, manganese, chromium and vanadium) that will drive renewable technologies in the energy transition. Of this list only lead/zinc are on the Nigerian strategic mineral list because of their reserves of about 10 million tonnes, however, some of these renewable minerals and rare earth metals are also found in Nigeria, such as graphite, copper, and manganese, but their reserves are not significant enough to be recorded.

6.2. Minerals trade and evolution of Organization of Minerals Exporting Countries (OMEC)

Minerals are often classified as those commodities under Standard International trade Classification SITC 2-digit sections 27 (crude industrial minerals) and 28 (metalliferous ores and scraps), which also includes concentrates. Metals are found in SITC categories 67 (iron and steel) and 68 (non-ferrous metals). SITC section 66 (non-metallic mineral manufactures) includes lime, cement, building stone, clays, and precious stones such as diamonds, while non-monetary trade in coin is found in SITC 96, and non-monetary trade in gold is found in SITC section 97. Generally, the first saleable product of mining are the concentrates, which are manufactured from mineral ores. Technically, ores are a concentration of mineralization found either close to the surface or deep in underground and are excavated from surrounding rock and brought to the surface via such energy-intensive and capital-intensive mechanical techniques ranging from relatively low-technology loaders and scrapers in the case of some industrial minerals to extreme high-technology processes to mine gold several kilometers underground. (Davis, 2010). The activities of global trade in minerals are published in the World Bank Development Index report, and as presented in figure 15, the global trade in ores and minerals from 1962 to 2016

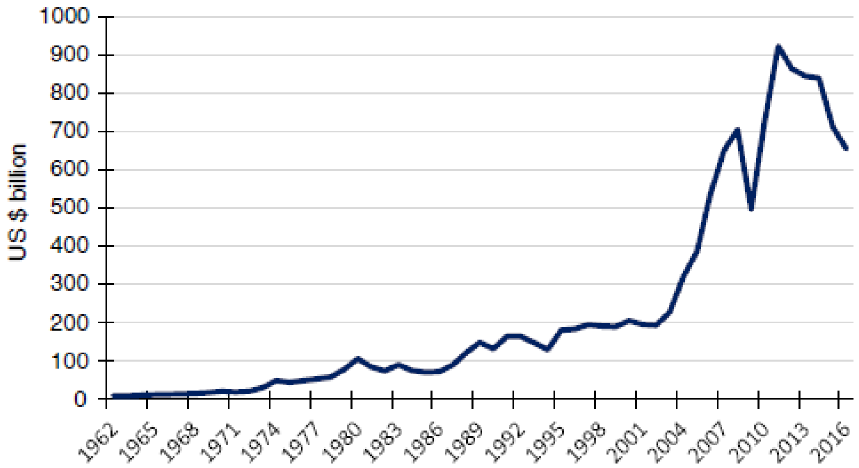


Figure 15: World exports of ores and minerals, 1962–2016 in US$ billion. Source: Crowson, 2019

showed upward trend from 2002 to 2012 which was attributed to changes in prices rather than movements in the volume of trade. However, a more economic measure of minerals trade is the share of mineral exports to total merchandise trade as shown in figure 16 shows the share of exports of products in sections 27, 28 and 68 (of SITC Rev.3) in global merchandise exports, as published in the World Bank's World Development Indicators. The figure shows erratically declining trend from the late 1960s to the early 2000s, but gradually took an upward trend thereafter dur to surge in prices and output from 2000.

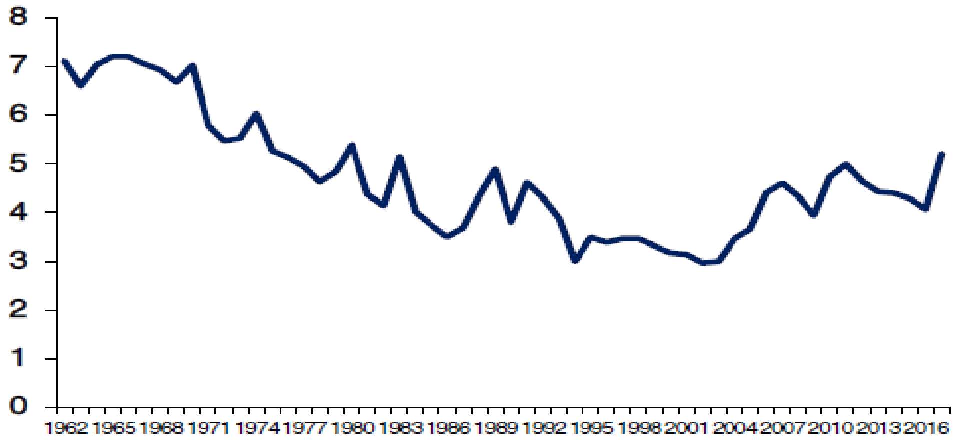


Figure 16: World exports of ores and metals as a% of total merchandise exports, 1962–2017. Source: Crowson, 2019

Figure 17 is a presentation on the percentage shares of minerals in total exports in some selected countries, and as is expected, Nigeria is missing on this list.

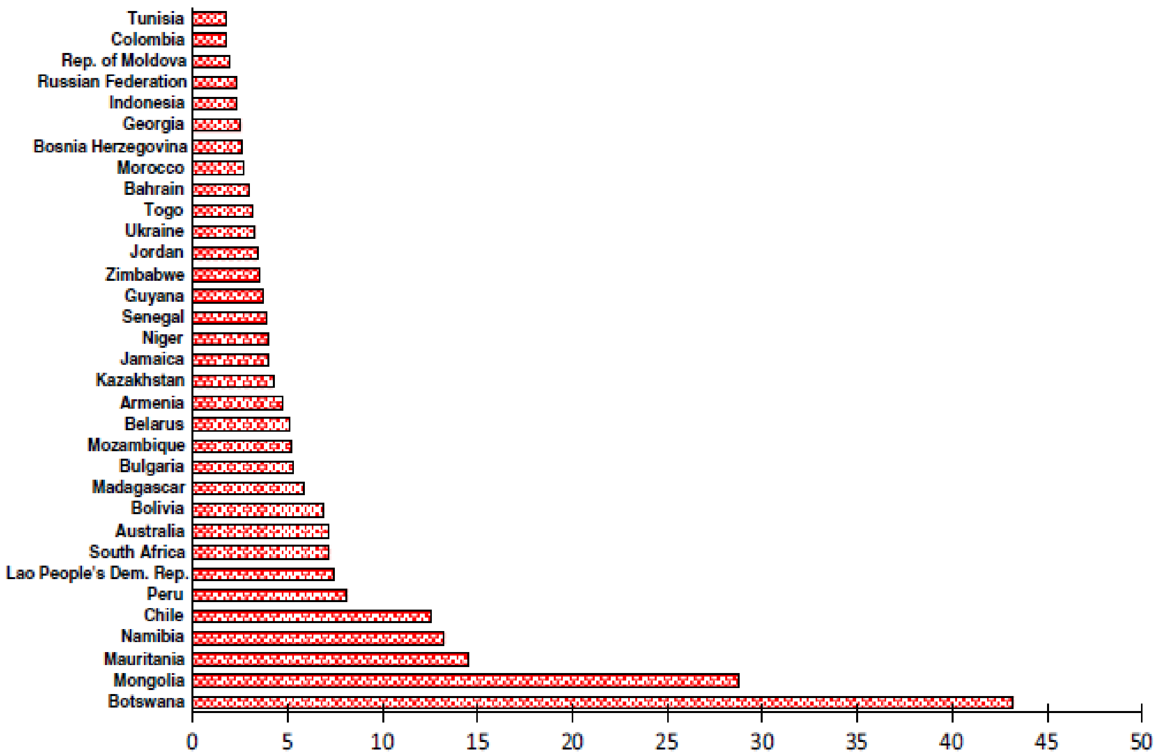


Figure 17: The percentage share of minerals in total exports in 2016. Source: World Bank Development Indicator. Source: Crowson, 2019

Given that the renewable energy which will drive the global economies will require these energy minerals and rare earth metals as raw materials for the development and manufacture of the technologies, Nigeria must go back to the drawing board to immediately review their strategies and structure very quick policies that will capture these critical minerals for exploration, production and refining, so that they can also be part of the new cartel that is already in view, the Organization of Minerals Exporting Nations (OMEC). Just as with the Organization of Petroleum Exporting Countries (OPEC), there are already discussions around Organization of Minerals Exporting Countries (OMEC) that will control the flow of transition minerals. These views are being explored by KPMG's global head of mining, Mr Hart, who is also of the view that there will be a global shift from the geopolitical power of the oil-dominated countries to those that produce minerals used in the production and storage of renewable power. This is because, access to these strategic resources will be politicized in the name of national security given the centrality of their use in broader economic development and technology innovation as well as energy transition. In Hart's view, the idea is not the formation of a mineral producing and price fixing cartel like OPEC but a collaborative body to ensure that countries which require critical minerals have sufficient access to supplies. This is because there is an under-appreciated risk to energy transition in that the supply of clean energy which depends on mined natural resources which are: "steeped in geological, geopolitical and governance challenges". (Treadgold, 2021). Nigeria, as a key member of OPEC cannot therefore be left outside of this new global powerhouse that will drive the energy transition. It must therefore ensure that it does not only join this move, but also work towards becoming a global key player in the new Organization, OMEC.

7. CONCLUSION AND RECOMMENDATION

The current energy transition besides achieving net-zero emissions of GHG and short-lived climate pollutants by 2050 – 2060, as its primary objective, also has sustainable economic opportunities for growing the global economy through innovative renewable technologies and job creations. According to IRENA and ILO, the current energy transition has potentials of creating about 24-25 million jobs by 2030 and 43 million jobs by 2050. Already, renewable energy employment worldwide has reached 12 million in 2020 from 11.5 million in 2019, with China leading at 39 per cent share of jobs worldwide in 2020, followed by Brazil, India, the United States, and members of the European Union. Other countries are Viet Nam and Malaysia, Indonesia and Colombia, with large agricultural supply chains for biofuels; and Mexico and the Russian Federation, where wind power is growing, while Nigeria, Togo, and South Africa in sub-Saharan Africa, are creating jobs in solar power. (IRENA, 2021). The renewable technologies that will drive the energy transition will rely greatly on energy minerals and rare earth metals, as presented in this paper. This will be the next global economic business, and given Nigeria's vast mineral resources, it is a very auspicious period for the country to go back to the drawing board to review its solids mineral policies towards actively participating in this new global business that will form the foundation of the current energy transition.

REFERENCES

[1] Acciona, (2019): How do greenhouse gases contribute to global warming? https://www.activesustainability.com/climate-change/how-greenhouse-gases-contribute-global-warming.

[2] Ague J, and Oristaglio M (2017): .Development of Hubbert's Peak Oil Theory and Analysis of its Continued Validity for U.S. Crude Oil Production Torren Peebles, https://earth.yale.edu/sites/default/files/files/Peebles_Senior_Essay.pdf

[3] Azobu, C and Jaiyeola, H (2019): Unlocking the Potentials of the Mining and Steel Sector in Nigeria, PWC Advisory Outlook, https://www.pwc.com/ng/en/assets/pdf/unlocking-potentials-mining-ngr.pdf

[4] Bhatia, S.C (2014): *Advanced renewable energy systems*, Woodhead Publishing India Pvt. Ltd.

[5] Britannica, (2020): Hydroelectric power: https://www.britannica.com/technology/cell-electronics

[6] World Economic Forum Insight Report, 2018

[7] Clean Energy Regulator (2021): Greenhouse Gases and energy. http://www.cleanenergyregulator.gov.au/NGER/About-the-National-Greenhouse-and-Energy-Reporting-scheme/Greenhouse-gases-and-energy

[8] Crowson, P (2019): Mineral Economics, World minerals trade: a comment https://doi.org/10.1007/s13563-019-00180-9

[9] Dairo, F (2020): The Mining Sector Roadmap – Reforms and Rewards https://www.dataphyte.com/latest-reports/extractive/the-mining-sector-roadmap-reforms-and-rewards/

[10] Davis, G.A (2010): Trade in Mineral Resources; World Trade Organization, Economic Research and Statistics Division, Staff Working Paper ERSD-2010-01, https://www.wto.org/english/res_e/reser_e/ersd201001_e.pdf

[11] ElBaz, O (2020): The Role of the Mining Industry in the Energy Transition, https://infomineo.com/mining-industry-in-energy-transition/

[12] EKT Interactive, (2020): Oil 101, https://www.ektinteractive.com/history-of-oil/

[13] Ericsson, M and Löf,, O (2019): Mining's contribution to national economies between 1996 and 2016, Magnus Ericsson & Olof Mineral Economics (2019) 32:223–250,

[14] EUANMEARNS (2018): Energy matters. energy and man part 2, http://euanmearns.com/energy-and-man-part-2.

[15] Galeazzi, Clara; Steinbuks, Jevgenijs; Cust, James. (2020). Africa's Resource Export Opportunities and the Global Energy Transition. Live Wire;2020/111. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/34946 License: CC BY 3.0 IGO

[16] Global Catholic Climate Movement, 2017: Why is the energy transition crucial? Why must we transition away from fossil fuels and the economy of extraction? https://catholicclimatemovement.global/why-is-the-energy-transition-crucial-why-must-we-transition-away-from-fossil-fuels-and-the-economy-of-extraction

[17] IEA (2021): From oil security to steering the world toward secure and sustainable energy transitions https://www.iea.org/about/history)

[18] IEA (2021) The Role of critical minerals in clean energy transitions, IEA Report https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[19] ILO, (2021): Renewable energy jobs have reached 12 million globally. https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_823759/lang--en/index.htm, 21

[20] IPCC (2021): Press Release on Climate change widespread, rapid, and intensifying https://www.ipcc.ch/site/assets/uploads/2021/08/IPCC_WGI-AR6-Press-Release_en.pdf, IPCC, 2021/17/PR

[21] Johnson, R, J ., Blakemore, R., and Bell, R (2020): The role of oil and gas companies in the energy transition, Atlantic Council, 2020

[22] Kesler, S.E (2007): Mineral Supply and Demand into the 21st Century. Proceedings, Workshop on Deposit Modeling, Mineral Resource Assessment, and Sustainable Development, https://pubs.usgs.gov/circ/2007/1294/reports/paper9.pdf

[23] KPMG (2014): Oil and Gas Industry Brief. KPMG Advisory Services.

[24] Kukreja, R (2021): What is sustainable energy? https://www.conserve-energy-future.com/ isrenewableenergysustainable.php

[25] Lombrana, L.M (2021): The Benchmarks Countries Must Hit to Reach Net-Zero Emissionshttps://www.bloomberg.com/news/articles/2021-02-01/the-benchmarks-countries-must-hit-to-reach-net-zero-emissions

[26] Lindsey, R & Dahlman, L (2020): Climate Change: Global Temperature, National Oceanic and Atmospheric Administration (NOAA), https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

[27] Mason, M.G, (2020): Renewable Energy: All You Need to Know, https://www.environmentalscience.org/ renewable-energy

[28] McCarthy, N (2017): The Soaring Costs of Climate Change, https://www.statista.com/chart/11673/the-soaring-costs-of-climate-change.

[29] Mining Africa (2021): These are the top Mining Countries of Africa, https://miningafrica.net/mining-countries-africa

[30] Ministry of Mines and Steel Development (2016): RoadMap for the Growth and Development of the Nigerian Mining Industry

[31] NDSU () Energy Sources: History, Selection, and Transitions,

[32] NDSU Central Grasslands Research Extension Center. https://www.ag.ndsu.edu/archive/streeter/Energy_Report/ Chapters/History.htm, 11/6/21

[33] Nhede, N (2021): How to stabilise the supply of minerals vital for the energy transition. https://www.smart-energy.com/industry-sectors/components/six-ways-to-ensure-a-stable-supply-of-vital-minerals-for-the-energy-transition/

[34] Ojo, G (2015): Nigeria An Outlook on the Mining Industry, Venmyn Deloitte

[35] Owen, A and Garniati, L (2016): The politics of investing in sustainable energy systems, https://www.sciencedirect.com/topics/engineering/sustainable-energy

[36] Oxford Business Group, (2019): The Report: Nigeria, 2019, https://oxfordbusinessgroup.com/nigeria-2019

[37] Oxford Group (2016): The Report-Nigeria: Digging deep significant and largely untapped mineral reserves aid goal economichttps://oxfordbusinessgroup.com/overview/digging-deep-significant-and-largely-untapped-mineral-reserves-could-aid-goal-economic.

[38] Oxford Group (2017): New roadmap for Nigeria's mining industry, https://oxfordbusinessgroup.com/overview/ uncovering-potential-new-roadmap-aims-help-industry-capitalise-its-substantial-and-diversified 10/29/21

[39] Rodrigue, J,P (2020): Energy Sources: History, Selection, and Transitions, https://www.ag.ndsu.edu/archive/streeter/Energy_Report/Chapters/History.htm;The Geography of Transport Systems, fifth edition, New York: Routledge, 456 pages. ISBN 978-0-367-36463-2, https://transportgeography.org/contents/chapter4/transportation-and-energy/energy-sources-evolution/ NDSU Central Grasslands Research Extension Center

[40] Shipley Energy (2021): Green, sustainable, clean, and renewable energy — what does it all mean? https://www.shipleyenergy.com/resources/energy-guides/green-sustainable-clean-and-renewable-energy-what-does-it-all-mean: Retrieved 6/16/21

[41] Sovacool, B.K (2017): The History and Politics of Energy Transitions Comparing Contested Views and Finding Common Ground, In: Arent D., Arndt, C, Miller M., Trap, F., and Zinaman, O (2017): *The Political Economy of Clean Energy Transition*, Chapter 2, University of Oxford Press

[42] Treadgold, T (2021): Goodbye OPEC, Hello OMEC. A Shift from petroleum power to minerals power, https://www.forbes.com/sites/timtreadgold/2021/05/04/goodbye-opec-hello-omec-a-shift-from-petroleum-power-to-minerals-power/?sh=97addb240057

[43] UNECE (2020): Pathways to Sustainable Energy, Accelerating Energy Transition in the UNECE Region, ECE ENERGY SERIES No. 67, 2020

[44] United Nations (2020): The race to zero emissions, and why the world depends on it, https://news.un.org/en/story/2020/12/1078612, 10/22/21

[45] Yale Environment 360, (2020): Extreme weather events have increased significantly in the last 20 years. Yale School of the Environment https://e360.yale.edu/digest/extreme-weather-events-have-increased-significantly-in-the-last-20-years,