Sustainable Supply Chain in The Energy Industry with A Focus on Finance

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Abstract- ***This paper aims at analyzing sustainability risks in relation to the supply chain in the energy business and how finance can support increase in sustainability. This field has been evolving in the last several years and more emphasis focuses on the use of renewable power sources and the impact on the Earth. One of the most significant of such reasons is the idea of introducing sustainable finance into the energy sector, in which the prospects for the provision of the necessary financial resources for the development of element energy sources are provided. An empirical analysis of Ardova Plc is used to explain the possibility of sustainable finance in eradicating the traditional energy product like petrol motor spirit (PMS) and encourage the use of more sustainable product like liquefied petroleum gas (LPG). Globally, sustainable financing mechanisms have been utilized effectively in the transition; through this innovation, Ardova has shown how green bonds and sustainable loans can work to support the shift toward cleaner energy. The transition to liquid petroleum gas identifies a new angle towards the mitigation of carbon emissions as an alternative to PMS for where fossil energy is still predominant. Furthermore, the paper investigates how a strategy of lowering carbon emissions, regarding the energy industry at least, consists of the minimization of Scope 1, 2, and 3 emissions. Scope 1 emissions are those controlled by the organization or by third parties where the reporting organization has direct authority over the relevant emissions; Scope 2 emissions are those resulting from the use of electricity, heat or cool generated by the organization; Scope 3 emissions are all other emissions related to the entire value chain of the reporting organization. Energy companies should therefore, ensure that they implement disciplined measures that would enable them ensure that they minimize their total emissions with regards to all the three scopes to ensure that they play their part in the improvement of the overall global emissions.***

I. INTRODUCTION

Energy is fundamental to our modern society because most economic and industrial processes require energy for them to proceed. However, the social impacts of conventional energy production especially from fossil fuels have not been well realized until now. Environmental costs such as global warming, air pollution and strip-mining requirement a sustainable industry that has the ability to reduce these impacts. Today's trends and the UN Sustainable Development Goals regarding climate change and the transition to net-zero emissions require a shift toward the use of sustainable energy.

Sustainability in the energy industry is a broader concept that requires a revolutionary change in the process of generation, transmission, distribution, and consumption of utilities too. The energy supply system or chain that begins with the sourcing of materials and ends with the provision of energy products to the consumer has its major source in the environmental impact.

Finance acts as an enabler in this shift towards improved energy systems as described above. Sustainable finance can therefore be defined as financial products and investment solutions that are planned to finance sustainable development or alleviate environmental and societal problems (Dowling & Lucey, 2023). In the energy sector, sustainable finance can therefore be green bonds, sustainable loan and often referred to as impact investments. However, with initiatives such as those of Ardova at corporate level, Africa is seen to offer a perfect ground through which the world can shift towards the use of renewable source of energy. The continent especially has rich sources of renewable energy such as solar energy due to the abundance of sunlight and wind energy since there is enhanced wind pattern. However, if harnessed well, Africa has the potential of becoming a hub of the world's energy producers, however, millions of its people have no access to steady electricity supply. That means by investing in renewable energy structures Africa has

not only an opportunity to meet its population's energy demands but also to head the worldwide renewable energy production. Nevertheless, this transition can only occur, as long as the above-mentioned challenges of limited financing, policies, and technical know-how are addressed.

Chapter 1: Energy Industry and sustainability Challenges

The energy sector occupies an important position in the global economy as it provides energy for industries, homes, transport and structures. However, some of the environment impacts has been observed to cause much concern. Fossil resources and the carbon emissions from the current power plants and other devices are some of the significant issues affecting the industry as the global society seeks to overcome crucial steps in climate change. To overcome these challenges, today there is a strong initiative promoting the concept of the efficient and sustainable energy sources that will replace traditional energy more and more actively. This chapter discusses global energy system, the issues of the energy sector and the shift toward sustainable energy solutions.

- Global Energy Landscape

Energy, in the contemporary society, is crucial for daily existence, a boast from which the global community requisition is incessantly on the increase due to factors such as population increment, increasing urbanization and industrialization. The IEA estimates that energy demand across the world has slowly trended upward in the past five years led by the emerging power houses especially from Asia and Sub-Saharan Africa which include china and India. It includes setting up energy needs with minimal reference to local conditions or usage, and the two principal fuels have remained coal, oil and natural gas. These fuels contribute to over 80% of the overall energy demand and offer most of the world's electricity, heating, and transportation energy.

While achieving the sustainable production of renewable energy is currently a global goal, fossil fuels dominate the world's energy market. This sector continues the reliance on the non-renewable energy resources which form the root of climate change. The emission of CO2 is being triggered through the burning of fossil energies for generation of electricity, industrial uses, and mobility, which cause global warming and air pollution (Zhang, & Umair, 2023). Petrol Motor Spirit (PMS) and diesel in particularly are some of the most consumed products in vehicle use and electricity generation making the challenge even worse.

There are hard-hitting environmental impacts coming from dependence on fossil fuels. The use of energy is the greatest source of greenhouse gases, with CO2 emissions from energy production alone contributing 59%. They help to increase global temperatures, severe weather conditions, melting of the polar ice and negativity affecting the whole systems (Hren et al, 2023).. Such a change has become critical since climate change is becoming a real threat to the environment and human society in equal measure.

- Real-Life Issues Being Experienced by the Energy Industry

There are several broad issues that the energy industry must solve in its efforts toward plugging energy deficits and adopting greener sources. These are complex problems of a technological, economic, political and social nature.

1.Carbon Footprint and Emission

Energy is one of the core issues of the economy with a major problem being carbon emissions. Burning of fossils fuels send carbon dioxide and other greenhouse gases to the atmosphere and thus fuels global warming. As stated by the IEA, the CO2 share of the energy sector is about 40 percent of total emissions globally (Zhang, & Umair, 2023). This places the energy industry as the largest producer of global climate change pollutants, and this calls for action.

Technologically, the main challenge is the high cost of installing renewable energy source. Such renewable technologies as wind, solar, and hydrogen power have become cheaper over the years, but their use on a mass scale requires a heck of a lot of money. For developing countries, financing the transition to sustainable energy future can often be very difficult much due to the following factors: inadequate capital, lack of technical know-how and lack of necessary infrastructure for scaling of Renewable energy projects.

In terms of social dynamics, people always land up opposing change. The fact is that in the prospering

demand for fossil fuels industries may also exist and the shift to clean energy may be perceived as a threat to employment. People employed in coal mines, oil refineries and other fossil fuel businesses are likely to be reluctant to embrace the changes necessary for a green transition that is needed to make such shifts popular among the people.

The urgency for delivering a sustainable energy future
Therefore, the question of a sustainable energy future cannot be divorced from concern here. Global warming spurred mainly using fossil fuel is one of the biggest threats facing the world's ecosystems and societies. This is the kind of crisis that the energy sector needs to take a stand and transition to cleaner, renewable energy sources.

Wind, solar and hydrogen power sources can present a part of the solution to this issue. Wind and solar energy specially are renewable, non-polluting and getting cheaper by the day. They can ensure availability of energy without compromising on emissions of carbon which are characteristic of fossil energy sources. Hydrogen use as a clean energy source currently being in its infancy, it forms part of the promising future solutions to power generation and mobility.

Energy Supply Chain Management Constraints
There are added complications due to the very nature of the energy supply chain. The energy supply chain includes several stages: such activities as mining or extracting the raw materials, processing the materials and transporting them to the market or selling them in the market. For every stage there is a cost attached to it in terms of the environment; for example, emission from mining and drilling through to losses incurred from having to transport fuel long distances.

The extraction and transportation of renewable energy are less burdensome on the environment and the social settings; however, some difficulties can be traced in the storage of the energy as well as in its integration and distribution. Again, the nature and availability of renewable sources of power such as wind and solar happen in intermittent basis, meaning that there is need for redesign of energy systems for storage of power and smarter systems.

These are issues within the supply chain, and they must be solved to make the energy sector sustainable and better. Working at each step in the supply chain, energy organizations can cut down on costs, minimize waste and emissions, and create a renewable energy future.

CHAPTER 2: SUPPLY CHAIN MANAGEMENT AND ACADEMIC PERSPECTIVE: ACCOUNTING FOR THE ENERGY INDUSTRY
The energy industry is being approached more and more with the aim of value creation from such a concept as sustainability. Global concern towards climate change and exhaustiveness of the natural resources demand for energy resources to be utilized sustainably in the energy sector than before. Hence in this chapter, consideration is given to the principal concerns of supply chain management that, if addressed, can offer contributions to minimizing the negative impacts of the energy business on the environment and to improving a cleaner energy system.

Sustainable supply chain in energy industry on the other hand is a process that encompasses the procurement, generation, delivery and use of energy in a manner that is commendable to the health of the environment, socially acceptable as well as economically realistic (Alsmadi et al,023). This approach initiates the social, environmental, and economical aspects from the procurement of the energy materials and resources down to the consumer level. Sustainable supply chains focus on low carbon usage, reduced or no wastage, rights for renewables and employment standards.

Sourcing Raw Materials:
Sustainable sourcing as crucial and challenging as the process is no more an issue of whether it should be but rather how it should be undertaken.
As for the construction of successful supply chain, there is nothing more crucial that procurement of materials in the right manner. In energy it embraces the procurement of fuels, minerals and any other resource with least impacts of the environment and ethical questions. For instance, the use of renewable energy resources such as wind, sun, water and biomass has become conventional to produce energy. Not only are these resources completely free of any pollutants

than that of the fossil fuels but also these are establish resources of energy in the long run.Logistics and Transportation: Transportation and its role in emissions. Transportation is another sub-sector of the overall energy supply chain since fuels are often moved for long distances to retail centres and other consumption points. This is generally followed by a high level of emissions, a major part of which is due to vehicles that run on fossil fuels. To more efficiently deliver consumers goods companies are developing technologies that cut emissions during the transport of energy goods.

Waste and Efficiency: Energy loss and its opposite, energy efficiency, are measured to find out how much of the useful heat generated can be delivered to the place it is needed.
The application of smart grid innovation is important in increasing the efficiency of energy use. These systems, using digital communication, identify local fluctuation in usage, thus, enhancing efficient flow of electricity and limiting energy consumption. In the same manner, batteries and other forms of pumped storage help to keep the excess energy; thus, the energy must be utilized during high demand.

The use of advanced technologies in energy supply chain is making the market to be more transparent and efficient. New generation technologies comprising of Artificial Intelligence (AI), the Internet of Things (IoT) as well as block chain are today being deployed in supporting supply chains.

Global vs. Local Supply Chains: Sustainability Implications
The energy supply chains can be differentiated depending on the fact whether they are global or local. International business supply chains consist of the physical transfer of energy resources, equipment and technologies across countries whereby some or all the operations may involve multiple links and/or long-distance transit. These global networks can be occasioned by geopolitical issues or barriers to trade, or even by the constraints of the infrastructure itself. Certainly, supply chain costs are higher when they are global because they use cross-border shipping which incurs high carbon footprint and there is relatively low power over environmental considerations at each stage.

Local supply chain sustainability is important for countries in Africa for instance where access to energy is a subject of concern. Local supply chain then means that more people will be employed and at the same time, emissions will be reduced in the society while more people especially in the underdeveloped regions will be able to access affordable renewable energy. Although local systems of accreditation can help improve quality in LAM countries, they can face such issues as restricted development of the correct infra structure, problematic financing, and inadequate regulation.

CHAPTER 3: FINANCE FOR SUSTAINABLE ENERGY – A CRITICAL ANALYSIS
The energy sector has remained one of the main sources of greenhouse gases emission for several years. While the world is faced with the problems of global warming vice and its effects ad needs to Industrial change towards cleaner sources of energy solutions. But the shift to clean energy infrastructure needs a lot of money on the side of financial capital. In this chapter, the author aims to discover the functions of finance in supporting the change to sustainable energy using several financial instruments as green bonds, sustainable power, and impact investment. Finance makes up the last puzzle of energy industry's sustainability and is crucial for financing more sustainable renewable energy projects, improving the performance of energy efficiency, and realizing long term environmental goals.

Finance: The Case of Energy Companies
Sustainable finance can further be defined as the action of delivering financial products and other financial assets where ESG factors have been incorporated in the provision while making decisions on the same. When applied in the energy sector, sustainable finance seeks to finance schemes which trigger the shift towards the efficient use of renewable energy sources and the minimization of carbon emissions in energy generation and utilization. In other words, the kind of financing options that are brought about to enhance sustainability, ensures the investment made in any financial assets or capital is in ways that will not hamper the environment and social well-being as capital grows (Raihan, et al 2023).

Over the years the concept of sustainable finance has received considerable attention with global climate targets. As a result, such concepts as sustainable finance has gained popularity at financial institutions, governments, and corporations. In particular, the renewable energy practices are expressed mostly in such instruments as green bonds, green loans and other instruments that target the financing of infrastructure with an aim of mitigating detrimental environmental effects.

Green Bonds and Sustainable Loans: Key Financing Instruments

The green bond is one of the most widely used instruments used in sustainable finance now. Green bonds are fixed income products available in public markets where borrowed funds have been raised with an objective to fund and /or rehabilitating projects with low carbon footprint. This kind of bonds are attractive to investors who plan to invest in their organization's sustainable development, climate change, renewable energy and energy efficiency ventures because it presents an opportunity to find for funding for such projects. For the energy sector, green bonds serve as its main avenue to attract the funds required for financing large investment projects in renewable energy production and storage including solar power plants, wind farms, and energy storage facilities (Flammer, 2019). Green Bonds have the potential of greatly increasing the rate at which clean energy technologies can be deployed, thus helping organizations move away from using fossil-based energy sources. In addition, green bonds tend to get backing from international standards and certifications, which makes the application of the fund's principal more accountable.

CHAPTER 4: SUSTAINABLE FINANCE AT ARDOVA PLC: A CASE STUDY

COMPANY BACKGROUND

Ardova has been a significant participant in the fossil fuel industry while lately coming to terms with the need for sustainability in the energy sector. Today, as the world was facing the problem of climatic change, Ardova has moved this company to try out other energy sources that may not be as pollutive as the current ones. One of the deviations has been the company's efforts to move from traditional fuels which are PMS to LPG which is a safer option and environmentally friendly energy source.

Sustainable Finance as well as the Switch to LPG

Another issue that spurred increasing attention in the recent past is the societal concerns on utilization of fossil products, and so; the company, through Ardova Plc, has directed more effort towards substitution of PMS with Liquefied Petroleum Gas (LPG), which is deemed to be a more efficient and environmentally friendly option (Adebiyi, 2024, December 26). But LPG is more acceptable to the environment and can contribute to the reduction of emissions of PMS and diesel as a fuel. In its strategic plan, the company says it will try to cut its dependence on petrol and diesel but will push for LPG as an energy source for domestic and industrial purposes.

To facilitate this transition, Ardova intended to look for funding through sustainable funding structures such as the green bonds and sustainable loans. They are all means of funding that are specifically targeting environmentally sustainable projects. For instance, green bonds are utilized on schemes with the objective of cutting back on CO2 emission or encouraging for clean technology. As a result, Ardova have been a major approach in financing this crucial element with the aim of building the LPG infrastructure especially the storage and distribution channels across the country and to ensure constant availability of this cleaner fuel.

Chapter 5: The Prospect and Limitations Towards Investment In Renewable Energy In Africa.

Africa has tremendous prospects for development through alternative source of power for better energy security. Having vast deposits of natural resources, the continent could turn into the rightful adopter of renewable energy sources like solar, wind and hydropower. The prospects of RE in the Africa region, challenges to embedding this trend, and investment opportunities to enhance the growth of sustainable energy technologies are also discussed here. Opportunities towards penetration of renewable energy in Africa. Africa is well placed to leverage significant renewable energy prospects, vital for occasioning energy destitution and lowering susceptibly to climate shift (Adebiyi, 2024, December 25). In the renewable resource availability, solar

energy is the most available resource in the continent. For instance, North Africa's Sahara Desert receives some of the highest solar insolation on this planet. As for this type of resource, they have been actively developed by countries like Morocco and Egypt, which built many solar farms. Morocco's Noor Complex, the largest concentrated solar power plant today is a clear demonstration of how solar energy is likely to revolutionize electricity production in Africa. Besides, solar power, African has prospects such as wind energy in its coasts especially, Kenya and Ethiopia. The Lake Turkana Wind Power in Kenya, the largest wind power station in Africa, therefore, shows that there are significant opportunities for developing large scale investments in wind energy.

Natural Gas as An Essential Input to Renewable Energy

Although today's Africa should embrace renewable energy, tomorrow's Africa cannot do without the help of Natural Gas as the transition fuel to power Africa's industrialization and energy mix. In Nigeria, Lawrence et al. (2024) examine the role of natural-based, the energy metrics system of natural gas in energy supply chain strategies and impact on the EU energy security system. Improving sigma metrics of the natural gas sector can lay the foundation for Nigeria's global competitiveness and, at the same time, drive investments in renewable energy. Lawrence et al.'s insights underscore the imperative for comprehensive systems that support the inter-connectivity of natural gas with renewable energy systems in Africa. These strategies help achieve two objectives – the first is to ensure that Africa abandons carbon intensive sources of energy in the long term while the second is to meet Africa's immediate energy needs. Forums, gas infrastructure investments, and development enable the emergence of new sources of financing and technical support for renewal energy programs in areas where there are infrastructural limitations.

Africa's Demand for Renewable Power Facilities

Indeed, there is no doubt that Africa requires a stable energy base for its growth and development. Yes, continent's population is still the most deprived one in terms of electrification – today more than 600 million people have no or limited access to electricity. This energy poverty holds back economic growth, prevents educational progress, and decreases health care benefits. Investing in renewable energy sources should be of paramount importance in Africa as this will enable provision of adequate power needed for the economic sectors including the business, industries and homes.

In addition, a sustainable energy infrastructure will enhance Africa's capability to achieve its development objectives in a manner that has low risks to the environment due to fossil fuel burn (World Investment Report 2023).

Opportunities for Investment

There are however signs that global investors are warming up to the opportunities that exist within Africa's renewable power generation capabilities. Various sources of funding which already exist at the international level include African development bank (AfDB) and Green Climate Fund (GCF) among others that support grants on renewable sources of energy across the continent. For instance, the AfDB has started such programs as the New Deal on Energy for Africa of which the primary goal is to increase electricity access and support renewable power solutions on the continent.

According to World Investment Report of 2023, it shows that by March 2021, Africa has attracted $ 134 billion in renewable energy investments in record time, with other multilateral organizations like the World Bank and European Investment Bank also funding Africa's renewable energy change (Adebiyi, 2021). Those institutions offer funding through lower interest loans, grants, and quasi-equity funds which assists in closing the funding gap (Fellmeth, 2020).

Private capital is also becoming more interested in financing renewable power in Africa. Many international firms are particularly drawn to the increasing demand for clean energy technologies, attractive rates of returns, and the favourable long-term outlook for renewable energy. Both the government and the companies are waking up to the reality that they must invest in energy solutions that will unlock the potential of the economy as well as ensure that the impacts of the energies on the natural environment are reduced to the barest minimum.

CHAPTER 6: FINANCE AWARENESS ON THE ENERGY TRANSITION IN AFRICA

The transition towards sustainable energy solutions in Africa is neither merely a technological nor policy reality, but also a financial one. Thus, for Africa to fully realize and enable renewable energy and make the energy transition feasible, there is a need for investment right from the upstream, through the midstream to the downstream markets. Investment on these assets such as transmission, distribution and grid systems are vital to creation of capacity, deployment of renewable, and overcoming energy deficits (Ren et al, 2023). Finance has a central part to play in driving the energy transition, and this is a process that is and will require policy intervention from both the public and private sectors, new types of institutional finance for renewable energy projects, and increased cooperation and integration across borders.

The Risks of Financing for Africa's Energy Transition

Of all the reasons for financing in Africa's energy transition that are explored in this paper, the imperative is clear. Nonetheless, the continent has a wealth of renewable energy generation potential; nevertheless, energy infrastructure remains underdeveloped: 618 million people in Africa are without electricity. Persistent use of the fossil energy sources inadequate attention and spending on the clean energy sources additionally contributes to the energy poverty. However, with increased urban and industrial output, the demand for energy has increased and this implies that significant capital must be pumped into the development of structures that will support the supply of energy and will at the same time be sustainable (Nur ilham, et al, 2022).

There is a strong need to mobilize resources for the investment in the amount and capacity of renewable energy generation facilities including wind farm, solar power plant and hydro-power station. Such projects entail heavy capital costs, unmatched by most African national governments and most private sector entities. Moreover, energy storage and distribution networks, transmission, and distribution grids need strengthening for integration of renewable energy systems to guarantee electricity delivery to customers (DEC 2024, IRE Journals).

However, international development assistance provides a substantive strategic role of supporting renewable energy projects in Africa apart from investment. The major players in the current African renewable energy industry are the International Finance Corporation (IFC) and USAID that support and fund improvements in renewable energy policies, infrastructure, and investments in various African countries.

CONCLUSION

Though the road map to a sustainable energy future in Africa is nothing short of arduous, opportunities for renewable energy can potentially in the future solve energy poverty, support economic growth and climate change. An essential factor in achieving this potential will be the function of finance (Adebiyi, 2020). Through innovative sources of funding including green bonds, climate finance, PPPs, impact investing and blending, Africa can unlock barriers to scale up investment in renewable energy. However, international capital and trained manpower will be crucial for enhancing the pace of the change.

Nevertheless, for such financial support to be fully effective, the governments of African countries should provide an appropriate environment through appropriate legislation and infrastructure. International investors and relevant financial institutions must keep paying attention to Africa's potential in renewable energy industry and fostering collaboration with relevant local governments to mitigate risks and promote that investment can act as a positive force towards realization of sustainable development goals.

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