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Assessment of Energy Diversification and Sustainability of Telecommunication Industry in Zambia

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Abstract:
Telecommunication industry in most sub-Saharan African countries like Zambia is highly dependent on grid and fossil fuels. However, grid power coverage in these countries is very low and mainly in urban areas and not very reliable. To keep the industry running continuously in both urban and rural areas fossil diesel generators are deployed, resulting into greenhouse gas (GHG) emissions. The use of fossil (diesel) to meet the daily energy needs for the telecommunication towers during load management periods and in zero electrification zones in rural areas does not only lead to environmental impact but also contribute to high operational expensive in telecommunication industry in most Sub-Saharan African countries. This has led to slow pace in expanding the industry especially in remote rural areas far from grid. Additionally, current removal of fuel subsidies by the Government of Zambia, climate change related effects such as droughts has led to low energy supply and Russian- Ukrainian war has exacerbated fuel prices. All these are currently impacting operation cost of telecommunication infrastructure. Therefore, this paper aims at assessing the energy diversification and sustainability of telecommunication industry in Zambia considering 4As (Accessibility, Acceptability, Availability and Affordability). A comparative assessment of telecommunication industry sustainability of Zambia with other SADC countries will be conducted using the 4As. Hence, the key in ensuring sustainability of energy on telecommunication industry is switching to renewable energy (RE) in Zambia. The main sources of RE which can be utilized for power generation in off-grid environments are Solar, Wind and Biomass.

Keywords: Fossil fuel, grid, greenhouse gas, Renewable energy, Telecommunication sustainability, Zambia

1. Introduction

The collaborative efforts of keeping up with the environment and reducing the consequences of climate change must focus greatly on reducing greenhouse gases (GHG) emissions and their precursors within the required regulations (Ojo, et al., 2017). In the past decade expansion of telecommunication industry has been at a fast rate, depending mainly on fossil fuel and main grid systems. As the industry is growing, anthropogenic carbon emissions are increasing. This way of generating electricity to power telecommunication infrastructure in Zambia and the rest of the world is number one contributor to greenhouse gas emissions (IEA, 2018). Fossil fuel use for generation of electricity is highly applicable due to low hydro-grid coverage in Zambia, leading to environmental and social impacts. SADC counties aims at ensuring that enough, low cost-effective energy systems are always available for continuous

economic driving and poverty reduction whilst maintaining efficient uses of resources for energy (SADC, 2016). Owing to this identification of renewable energy sources (RES) for generation of electricity for domestic and industrial is going on. RES contribute to the sustainability of areas as they bring about socio-economic and environmental benefits (Rio & Burguillo, 2008). Analysis on the socio-economic benefits of renewable energy was done by the International Renewable Energy Agency (IRENA) from 2011, focusing on the creation of employment. In the same analysis skills covered aspects like gross domestic product (GDP), welfare, economic value creation and improved livelihoods (International Renewable Energy Agency, 2017).

In accordance with the United Nation sustainable development goals of 2015, energy importance for global sustainable development is highly outlined in Sustainable Development Goal 7 (SDG7) as it addresses the issue of affordability and reliability of energy for everyone. The targets under SDG7 are broken down in to three parts, with part one (7.1) being to ensure that universal access to affordable, reliable, and modern energy services is achieved by 2030. The second part (7.2) focuses on having high increase in the share of renewable energy in the global energy diversification by 2030. The third part (7.3) of SDG7 looks at doubling global rate of energy efficiency improvement by 2030 (ITU, 2017; ITU, 2017; ITU, 2017).

Globally telecommunication industries in their respective operations have direct impact on the environment, social and economic. The social impact is on the provision of jobs to the community. The economic impact field is on the provision of telecommunication services and products. Whereas the environmental field impact is the most significant on the telecommunication companies as it contributes directly and indirectly to the environment. Due to high energy consumption, by 2030 telecommunication companies will be responsible for 2% of the global greenhouse gas (GHG) emissions (Tataru, et al., 2020). In the telecommunications system the main element in energy consumption and GHG emissions is the Base Transceiver station (BTS). Cost and GHG emissions can be reduced by evaluations and development of interventions and technical solutions like renewable energy basing on the energy requirements and the renewable energy source available (Lubritto, et al., 2011). Installation of off-grid hybrid systems on telecommunication systems can significantly reduce energy cost and CO2 emissions (Ristic & Bosic, 2018)

This paper aims at assessing the energy diversify, sustainability and challenges of telecommunication industry in Zambia considering four (4) Telecommunication Aspects (4TAs) approach based on sustainability indicators. The method has been adopted based on arguments that for any Telecommunication System to be sustainable, it must adhere to the four aspects related to 4TAs. The method consists of four telecommunication aspects (4TAs); Telecommunication Accessibility, Telecommunication Acceptability, Telecommunication Availability and Telecommunication Affordability. The 4TAs proposed approach addresses the key sustainability pillars; Social, Economic and Environmental factors. A comparative assessment of telecommunication industry sustainability of Zambia with other SADC countries will be conducted using the 4As. These factors are essential of achieving telecommunication sustainability, in a path that is environmentally and socially acceptable and economically and technically viable which is feasible for sustainable telecommunication sector. Hence, the finding of the analysis will play key role in providing basis for decision making and policy formulation including understanding the current and future challenges in local telecommunication sector and in addressing these issues. Additionally, the findings will help in making informed decisions towards achieving sustainable telecommunication sector of the country.

2. Sustainability Assessment of Telecommunication Industries in Zambia

The Zambia's telecommunication industry like most African Countries is currently facing numerous energy challenges due to rapid growth in demand and technological development, lower electricity grid accessibility as the result of lower grid coverage across the country including electricity deficit due to highly dependent on hydropower which in the past few decades due to water scarcity that has been affecting country's hydrological system. The country has been experiencing energy deficit (**figure 2.1**) due to lower generation from main hydropower plants due to droughts and climate change effects (Energy Regulation Board, 2021). Hence, the telecommunication sector is highly dependent on fossil fuels which is leading to environmental and social issues due to rising greenhouse gas emissions.

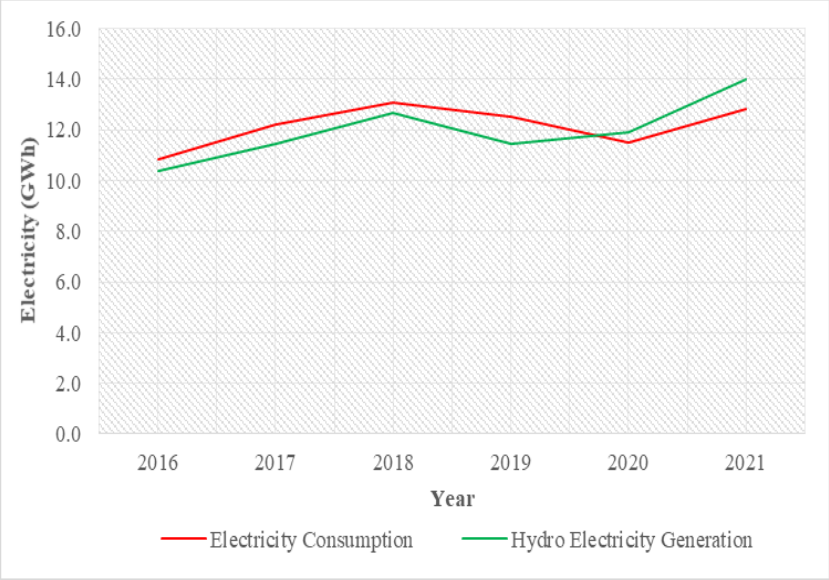


Figure1: Hydropower Electricity Generation vs Consumption in Zambia (Energy Regulation Board, 2021)

Therefore, for national coverage energy accessibility at affordable rate is one of the main issues in the sustainable telecommunication sector as it is linked to economic, social and environment aspects (World Energy Council, 2007). Accessibility effects to clean, reliable, and affordable electricity are considered to improve the telecommunication sector. The economic growth that can be impacted by the availability of energy is represented by economic aspect and society aspect being presented by development prospect (Bowa, et al., 2021).

The survival of Zambia's telecommunication industry is mainly dependent on hydro-grid, which is also the main source of electricity supply across the country (International Labour Organization, 2021). However, with current climate change, increased temperatures and droughts that faced Zambia in the past few years, the hydro-grid is facing huge challenge in meeting the current energy demand and has resulted in long hours of load shedding (8-15hours per day) leading to reduced reliability and the grid coverage is usually in urban areas with less in rural areas. To meet power demand on telecoms infrastructure, in urban and rural areas diesel generators and backup batteries are used to keep the network running. This way of powering telecommunication infrastructure is very expensive and contributes to wild wide greenhouse gas emissions (IEA, 2018). Zambia like any other developing country has low usage of modern form of energy (renewable energy) and great dependence on unclean form of energy is a phenomenon. As of 2017 renewable energy capacity for Africa was at 23% (UN, 2018). Up to today the capacity of renewable energy has not increased much. Therefore, Telecommunication expansion in rural areas has been a great

challenge in Zambia and most developing African countries. In 2018 statistical data showed that only 3% of the rural population and 45% of the population had access to grid power (Mudenda, et al., 2018).

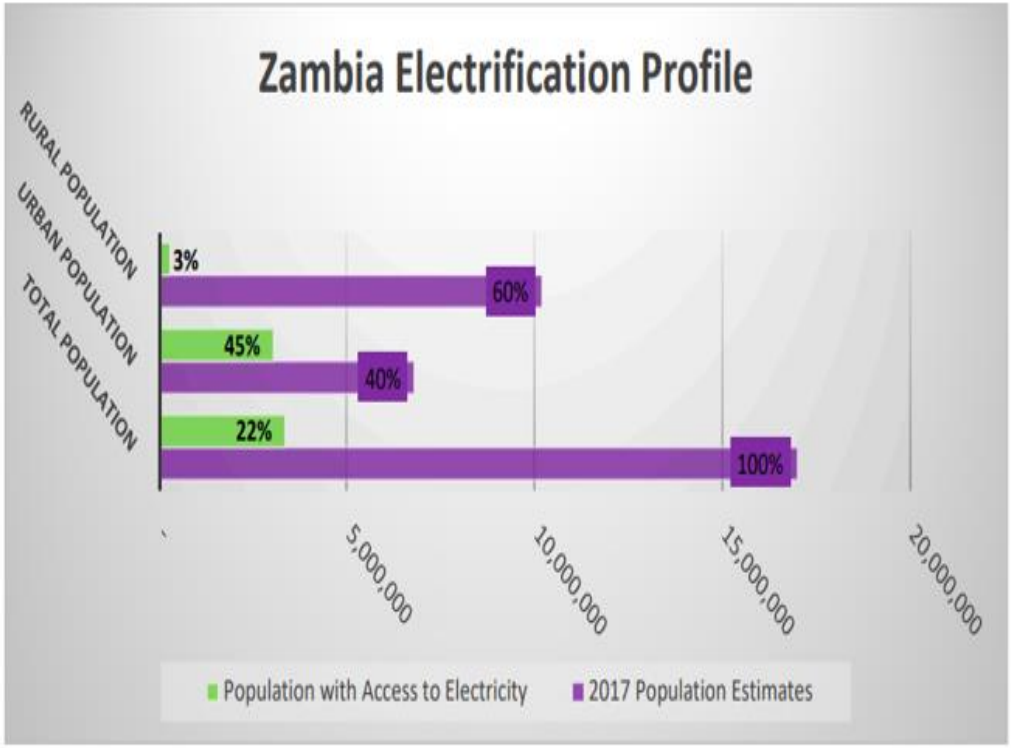


Figure 2: Populations with access to electricity in 2018 (Mudenda, et al., 2018)

AS can be seen from figure 2, from the statistical total population of 100% the total percentage electrification was at 22%. Hence, Telecommunication expansion using grid has been a very big challenge in Zambia. Hydro Grid power is highly acceptable in Zambia. However, availability and accessibility are mainly in urban areas. Fossil diesel used for powering the infrastructure is not just unclean, but very expensive and unreliable in Southern Africa. Hence telecommunication sector sustainability is one of vital factors in Zambia due to its link to social, economic, and environmental aspects. According to Bowa et al (2021).

- ***Social Aspect***; measures the impact of access to clean, affordable, and reliable electricity on improving quality of telecommunication industry and human well-being.
- ***Economic Aspect***: reflects the impact energy availability may have to telecommunication sector development prospects and economic growth of nation and society. According to literature (Njam & Cleveland, 2003), it is widely agreed that access to clean, reliable and affordable modern energy services such as electricity is vital for economic development and poverty alleviation for developing countries.
- ***Environmental Sustainability:*** is used to reflect the impact telecommunication systems contribute to overall environment due to energy systems being used for electricity generation. The present energy systems across the global are the major drivers of environmental issues such as climate change. Hence, uses of fossil fuel in telecommunication sector electricity mix pose a greater risk on the environmental sustainability as compared to using low-carbon renewable energy technologies.

Table 1 below illustrates the 4TA's sustainability indicators and criteria adopted for assessing sustainability of SADC member states telecommunication industry performance.

Table 1 Summary of 4TA's Zambia Telecommunication Industry Sustainability Indicators and Criteria

ASPECTS OF 4A'S	ISSUES	SUSTAINABILITY CRITERIA & INDICATORS
ACCEPTABILITY	Global Warming	1) Policies on renewable energy technologies in telecommunication sector (checklist) 2) Renewable energy share in telecommunication electricity generation (%) 3) CO_2 emission per base station (t CO_2/base station) 4) CO_2 emission (ktCO_2/year)
ACCESSIBILITY	Access to Modern Communication Services and Future Access Targets	5) Communication Access rate (%) 6) Communication Access per province 7) Communication Access Targets
AVAILABILITY	Communication & Energy Security	8) Diversity in Telecommunication players (Companies) 9) Diversity in Telecommunication Electricity generation mix (% share of each fuel type) 10) Diversity of fuel in Telecommunication Electricity generation (Shannon Wiener Index) 11) Dependence on imported fuel for electricity generation ▪ Self-Supply Sufficiency of Electricity (%) 12) Future Share of Renewable Energy Targets
AFFORDABILITY	Communication Affordability	13) Communication Prices ($/minute) 14) Data Bundles per MB prices

2.1 Acceptability

A. Policy on RET in Telecommunication Sector
B. RE Share in Telecommunication Electricity Generation
C. CO2 Emission per Base Station
D. CO2 Emission Sector

2.2 Communication Accessibility in Zambia

A. Communication Access rate (%)
B. Communication Access per province
C. Communication Access Targets

2.3 Communication Availability in Zambia

A. Diversity in Telecommunication players (Companies)
B. Telecommunication Penetration Levels in Provinces
C. Diversity in Telecommunication Electricity generation mix (% share of each fuel type)

3 Energy Diversification

The goal of global sustainability is the ability to deliver affordable energy whilst raising the living standards of global population by increasing the efficiency of energy and implementation of renewable energy in the energy mix (ITU, 2017). Renewable energy contributes greatly to enhancement of energy security and mitigating anthropogenic emissions of carbon dioxide. Carbon dioxide contributes highly to greenhouse gases (Paravantis & Kontoulis, 2020; Okundamiya, et al., 2014). The main issue in energy on telecommunications industry is sustainability (Mohanty & Moreira, 2015).

In Zambia sources of renewable energy other than hydro are Solar, Wind and Biomass. However, utilization of wind for power generation is zero (IRENA: International Renewable Energy Agency, 2020). The country's average solar insolation is 5.5Kwh/square meter/day, with approximately average peak sunshine between 6 and 8 hours/day (Mwanza & Ulgen, 2021) . Therefore, the most appropriate source of energy which can easily be utilized on telecommunication industry is solar and wind. Using these sources of RE, a hybrid solar-wind energy system can be developed to increase the efficiency and reliability of the system (Jenkins, et al., 2019). From figure 3, the highest annual average solar horizontal irradiation is around the region of Luapula and Northern regions. The regions with the lowest average annual direct solar irradiation are Eastern and some parts of Central and Northwestern (Mwanza & Ulgen, 2021). From figure 3, it can be seen that Solar energy can be very useful in the generation of power for telecommunication sites.

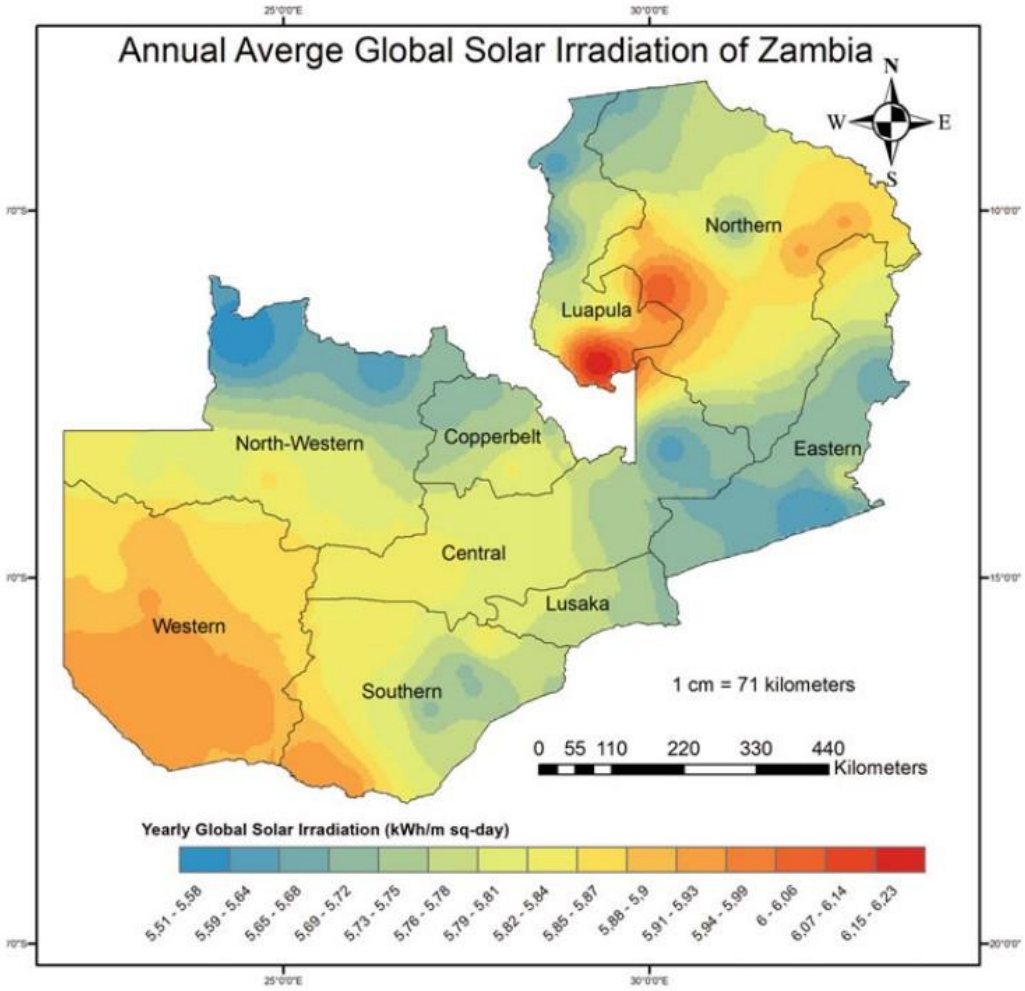


Figure 3: Annual Horizontal Solar Irradiation (Mwanza & Ulgen, 2021)

3.1 Urban Energy Diversification

In Zambia by the end of 2021 the total number of telecommunication towers were at 3417 of which IHS had1768, leading by 52% and Infratel trailing with 1253 towers (Zambia Information and Communication Technology Authority, 2021)`. The tower growth trend for all companies is as shown in Figure 4. In this year,2022 the biggest tower-co company IHS has continued to construct more towers and the number has increased to around 1798 telecommunication towers. Of the 1798 towers 20 sites are powered by grid and batteries only whilst 1528(84.98%) of urban sites are powered by Grid-diesel generators and network batteries. The average diesel consumption is around 83,700 Liters per month.

Taking all sites with diesel generators in to account the total quantity of fuel consumption per month is very high.

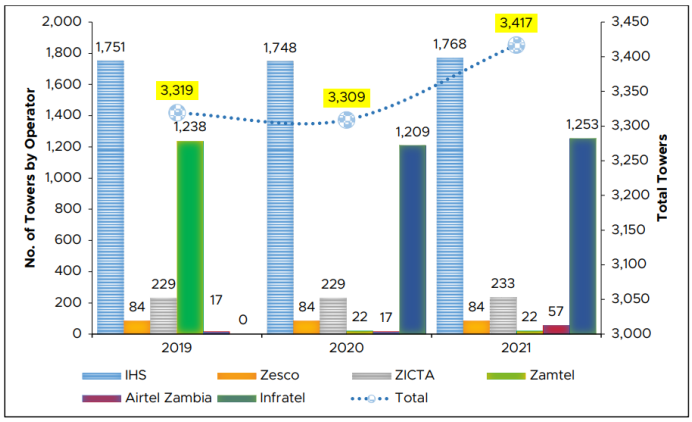


Figure 4: Trend of tower infrastructure:2019 to 2021 (Zambia Information and Communication Technology Authority, 2021)

3.2 Rural Energy Diversification

The energy mixes on the rural sites are solar-diesel generator and battery. The number of rural sites under IHS portfolio is around 269 (14.96%), with the average monthly diesel consumption of around 253,000Litres. Owing to this management of 14.96% of rural sites contributes 75.14% of carbon emissions. 24.86% of emissions came from the management of 84.98% of sites in urban areas. From diesel consumption per month, the system is not highly optimized and in accordance with the estimation of Global e-Sustainability Initiative (GeSI), the Information and communication Technology (ICT) sector will give by 2030 substantially higher contribution of carbon dioxide emission and our Zambian ICT if not controlled will not be an exception (Tataru, et al., 2020).

Introduction of highly optimally designed hybrid power systems on Zambia's ICT sector can be more cost-effective and reliable (Jenkins, et al., 2019)

D. Diversity of fuel in Telecommunication Electricity generation (Shannon Wiener Index)
E. Dependence on imported fuel for electricity generation
F. Self-Supply Sufficiency of Electricity (%)
G. Future Share of Renewable Energy Targets

3.3 Communication Affordability in Zambia

H. Communication Prices ($ talk time/minute)
I. Data Bundles per MB prices

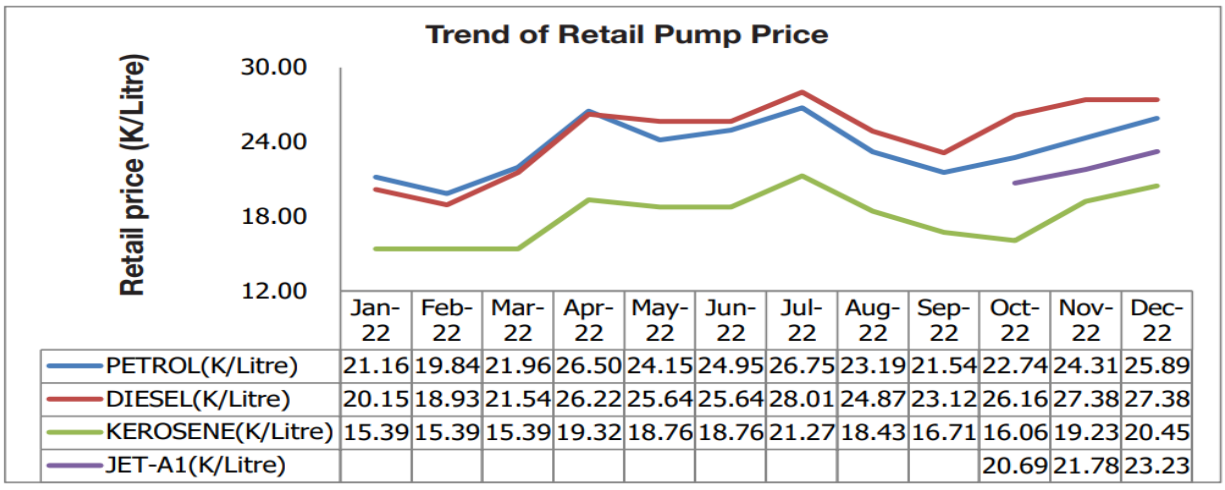
a. Fuel Prices

Zambia's fuel price is among the highest. From the statistical data of 2008, Zambia had the highest pricing as can be seen in table 2. Diesel pricing parameters per liter (Product Basic Cost, Transport service Differential, (Government Levies, Duties, Taxes), Oil Company margin, Dealer margin and Retail pump price) were the highest as compared to the rest of southern African countries (Whitworth, 2011).

Table2: Southern Africa Comparative Diesel Prices, June2008 (Whitworth, 2011)

Diesel/Gasoil (US$/liter)	*Botswana*	*Malawi*	*Mozambique*	*Namibia*	*RSA*	*Swaziland*	*Tanzania*	*Zambia*
Product Basic cost	1.19	0.96	1.05	1.04	1.04	0.99	1.05	1.48
Transport Service Differential	0.08	0.22	0.01	0.01	0.01	0.02	0.01	0.09
Govt. Levies, Duties, Taxes	0.06	0.34	0.16	0.19	0.24	0.26	0.44	0.55
Oil Company Margin	0.05	0.08	0.12	0.05	0.05	0.05	0.09	0.11
Dealer Margin	0.06	0.06	0.09	0.05	0.08	0.06	0.05	0.07
Retail Pump Price	1.44	1.67	1.43	1.34	1.42	1.37	1.63	2.3

In Zambia the cost of fuel has been very unstable and mainly with the upward trend. From figure 5, it can be seen that in the year 2022 fuel pump price was changing nearly every month.



	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
PETROL(K/Litre)	21.16	19.84	21.96	26.50	24.15	24.95	26.75	23.19	21.54	22.74	24.31	25.89
DIESEL(K/Litre)	20.15	18.93	21.54	26.22	25.64	25.64	28.01	24.87	23.12	26.16	27.38	27.38
KEROSENE(K/Litre)	15.39	15.39	15.39	19.32	18.76	18.76	21.27	18.43	16.71	16.06	19.23	20.45
JET-A1(K/Litre)										20.69	21.78	23.23

Figure 5: Trend of fuel pump price in Zambia (Energy Regulation Board, 2022)

The increase in the cost of energy directly affects the cost of production in many business sectors and the telecommunication sector is not an exemption. The communication rates are expected to soar together with the increase in energy supply rates.

In December 2021, the government of Zambia removed the subsidies from fuel to secure a bailout from the International Monetary Fund (IMF). This caused a sharp rise in pump price by 20% (Clifford, 2021).

Owing to this, the cost of running telecommunication infrastructure on fossil fuels went up by 20%.
As at 31st December 2021 and 2022 the regional diesel price was as shown in figure 6. From figure 6, it is evident that the average price of diesel in 2021 and 2022, Zambia was among three countries with high diesel price per litter. The high diesel price meant that the operation cost in the running of telecommunication industry was also high.
In July and August 2024 fuel price in Zambia reached the highest. This affected the cost of running telecommunication industry, especially that county wide load shedding went up to 20 hours per day (Zulu, 2024).

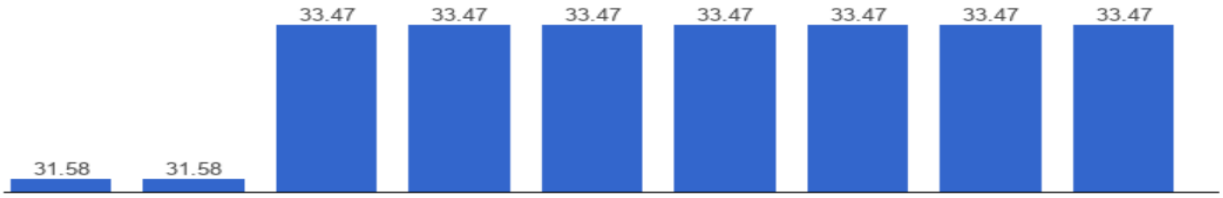


Figure 6: August to September,2024 fuel prices (com, 2024)

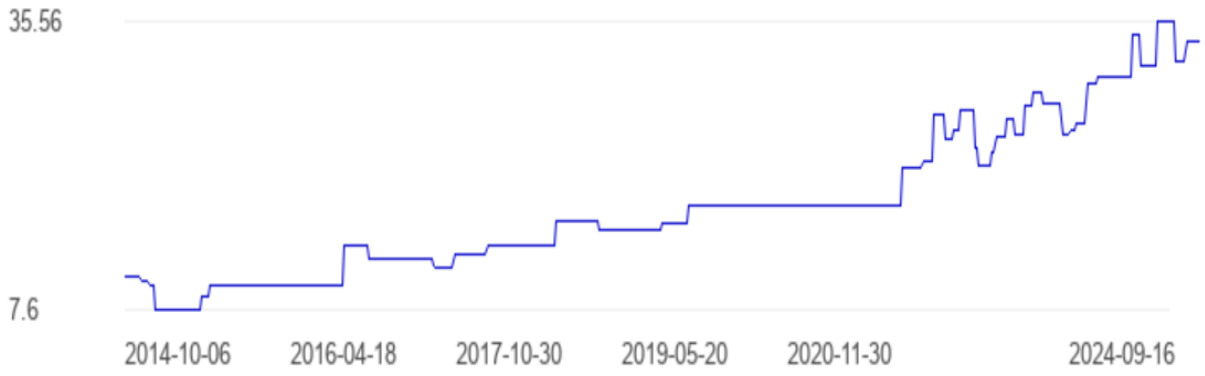


Figure: 7 Fuel price trends from October, 2014 to September 2024 (com, 2024)

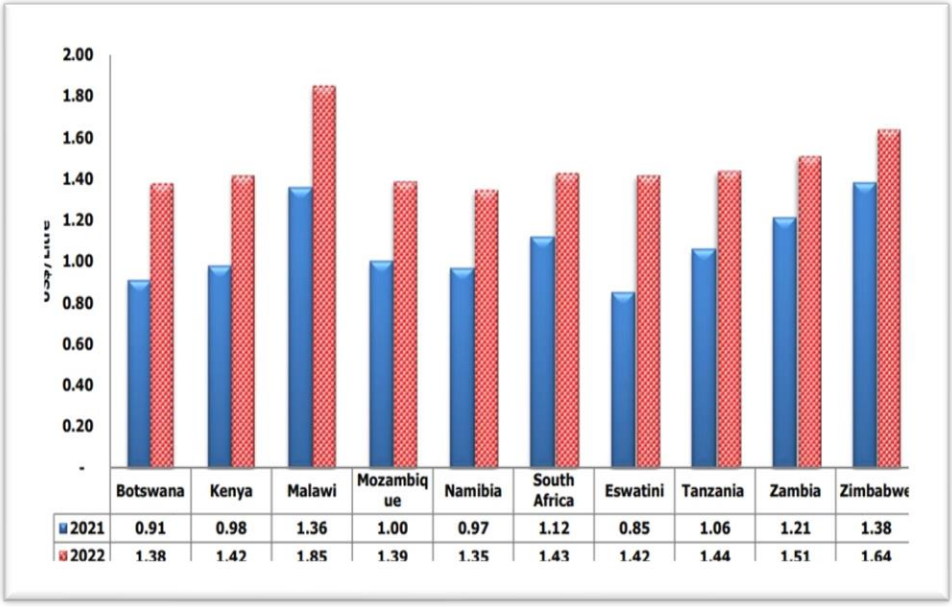


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Figure 8: Regional fuel price comparison for Diesel (Energy Regulation Board, 2021)

Before war broke out between Russia and Ukraine, global energy prices were increasing at relatively low rates due to factors like, low supplies of energy, COVID and increasing tension between Russia and Ukraine. The oil prices were stable prior to the war in the range of US $80 to US$95 per barrel.
The graphical presentation is as shown in figure 9. From figure 10, when war broke out oil prices increased sharply exceeding US$100 per barrel (Balbaa, et al., 2022).

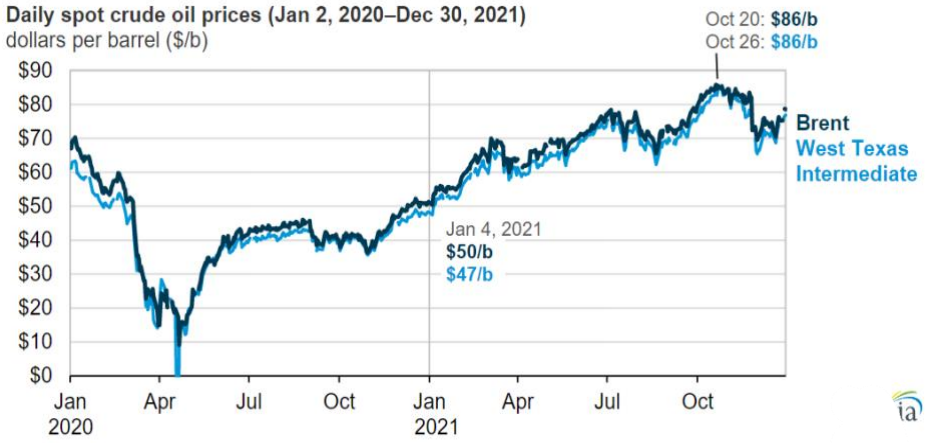

Figure 9: Crude oil prices from January 2, 2020, to December 30,2021 (Bi aa, et al., 2022)

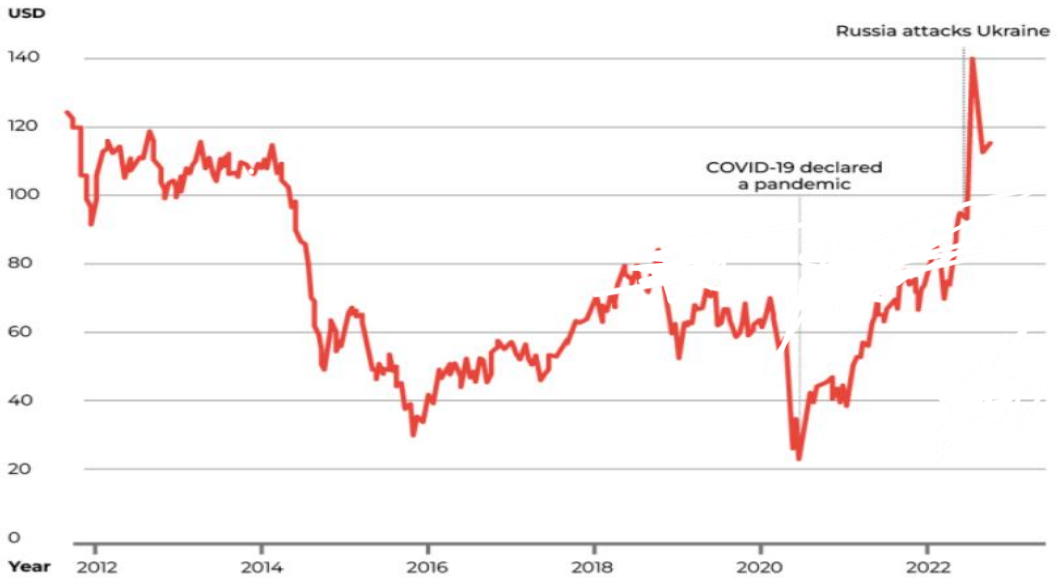

Figure 10: Crude oil prices before and after the war (Balbaa, et al., 2022)

From figures 9 and 10 stability of fuel prices globally is a big problem, leading to difficulties in running industries. This has a very big impact on Zambia in running businesses like telecommunication on 24 hours basis. Zambia has been experiencing unstable pump prices and recently the price rose sharply from ZMK 31.58 to KMK 33.47 per liter (com, 2024). Owing to this, introduction of hybrid power systems on Zambia's ICT sector can be more cost-effective and reliable (Okundamiya, et al., 2014) .

4 Infrastructure Comparative

Mobile sites in Zimbabwe and Zambia went up from the year 2016 and 2018. Zimbabwe had the most sites per 1000 population in 2018. However, Zambia increased very fast from low base and had

subsequently more fourth generation(4G) sites. In the same period data was not publicly available in Tanzania and South Africa. However, from press estimates the number of sites in Tanzania were extremely low in 2018. South Africa had a very good number of sites in 2016 and to support high speed mobile broad band, operators have been rolling out more infrastructure (Robb & Paelo, 2020). The number of sites per 1000 population between 2016 and 2018 is also as shown in figure 11.

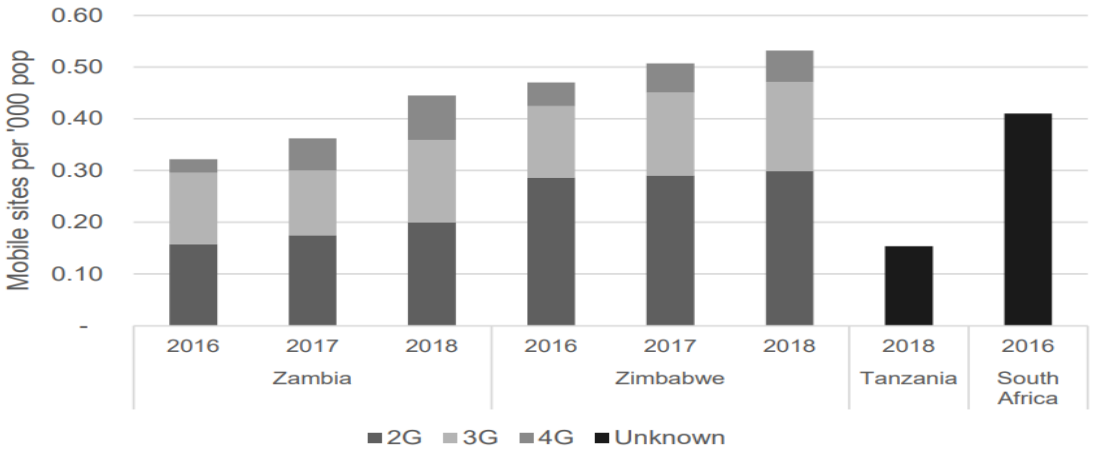

Figure 11: Mobile sites per 1000 population (Robb & Paelo, 2020)

From figure 11 Tanzania with low number of sites had less impact on the environment. The GHG impact on the environment was quite high for Zimbabwe, South Africa, and Zambia.

5 Conclusion

The telecommunication sector in Zambia is highly dependent on fossil diesel generators and Grid. Therefore, the sector can be more sustainable by switching to renewable energy in rural and urban areas. Implementation of renewable hybrid power systems on telecommunication sites can highly reduce GHG emissions and the cost of running the infrastructure.

Other than hydro use, other forms of renewable energy sources which can enable sustainability of telecommunication in Zambia in case of droughts and unplanned disturbances in fuel supplies are Sun, wind and Biomass. These three renewable sources are accessible, available acceptable and affordable

The GHG impact on the environment is higher in countries with high numbers of mobile sites per 1000 population and more reliant on fossil fuel.

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