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RESEARCH ARTICLE

POWER SECTOR MANAGEMENT FAILURE AND LOAD SHEDDING IN ZAMBIA

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Abstract

This paper examines the management failures within Zambia's power sector and their direct linkage to the persistent issue of load shedding. It highlights the critical role of ZESCO, the state-owned utility, in navigating financial constraints while attempting to meet the electricity demands of both domestic consumers and export contracts. The study identifies key factors contributing to load shedding, including inadequate infrastructure, demand forecasting failures, and political influences that prioritize short-term gains over sustainable energy solutions. Furthermore, the paper discusses the potential of diversifying energy sources, such as solar and wind, to mitigate reliance on hydroelectric power and enhance resilience against climate variability. Recommendations for comprehensive strategies to address the energy crisis and improve load management are provided, emphasizing the need for long-term planning and investment in renewable energy initiatives.

Introduction:-

The ongoing challenges faced by Zambia's power sector, particularly with respect to load shedding, have been heavily influenced by ZESCO's financial and strategic decisions. ZESCO, the state-owned power utility, has struggled with substantial debt owed to Independent Power Producers (IPPs), compelling the company to prioritise revenue generation through power exports. These exports, aimed at generating foreign currency to service the debt, have had the unintended consequence of reducing the electricity available for domestic consumption, thereby exacerbating load shedding within the country. This delicate balance between financial obligations and the need to maintain a stable domestic power supply highlights the complex operational environment in which ZESCO operates. The situation has sparked significant debate, underscoring the challenges of managing a critical public utility under financial strain, and raising important questions about the long-term sustainability of such strategies (Lusaka Times, 2024; Times of Zambia, 2024).

Load Shedding

Load shedding or otherwise load management refers to the intentional, temporary interruption of electricity supply to certain areas or sectors to prevent the entire power grid from collapsing when the demand for electricity exceeds the available supply. This practice is often implemented by utility companies as a last resort to maintain the stability of the electricity grid.

Causes Of Load Shedding

There are various drivers of load shedding among them; supply-demand imbalance, maintenance works and environmental as well as weather conditions.

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Supply-Demand Imbalance:
The primary cause of load shedding is the mismatch between electricity demand and supply. This imbalance can occur due to:

1. **Insufficient Generation Capacity**: Power plants may not generate enough electricity to meet demand, especially during peak usage times or when demand unexpectedly surges.
2. **Fuel Shortages**: Power plants may lack the necessary fuel (coal, natural gas, etc.) to operate at full capacity, leading to reduced power generation. A case in mind is that of Ndola Energy Corporation which shut down its power plant due to lack of supply of Heavy Fuel Oil(HFO), following the change in business model at Indeni.
3. **Technical Failures**: Unexpected technical issues, such as equipment failure, can lead to a sudden drop in power generation capacity. Although there is no evidence of this occurrence in Zambia, intuitively technical failure can be cited owing to the aging electricity infrastructure which requires attention.
4. **Transmission Bottlenecks**: Even if power is available, limitations in the transmission infrastructure can prevent it from reaching consumers, necessitating load shedding in certain areas. The constraints on the transmission interconnectors between Zambia and Zimbabwe as well as Namibia have negatively affected power imports thereby exacerbating the load shedding.
5. **Maintenance and Upgrades**: Scheduled or emergency maintenance on power plants or transmission lines can temporarily reduce available electricity supply, requiring load shedding to balance the grid. The scheduled maintenance at Maamba has led to a shut down of one its machines hence worsening the power supply situation in the country.
6. **Environmental and Weather Conditions**: Extreme weather events, such as heatwaves, cold snaps, or droughts, can increase demand or decrease supply, particularly in regions relying on hydropower, where water levels are crucial. This is the case for Zambia. Its dependence on hydro power generation has been impacted by droughts leading to low water levels in the Kariba and ItezhiTezhi water reservoirs necessitating a rump down on energy generation and consequently resulting into load shedding.

Power Sector Management Failure And Its Impact On Load Shedding
Strategic management failures at ZESCO, Zambia's state-owned electricity company, have significantly contributed to the persistent issue of load shedding in the country. These failures manifest in several critical areas, including inadequate infrastructure investment, poor demand forecasting, and ineffective maintenance practices.

Inadequate Infrastructure Investment
One of the most significant strategic management failures at ZESCO is the insufficient investment in infrastructure to expand generation capacity and upgrade transmission networks. Despite the growing demand for electricity in Zambia, ZESCO has not kept pace with necessary investments to meet this demand. This lack of investment has resulted in an over-reliance on aging infrastructure, which is prone to frequent breakdowns, leading to reduced power availability and, consequently, load shedding (Mundia & Kaluba, 2018). The failure to proactively invest in diverse and modern energy sources, such as solar and wind, has also exacerbated the problem, leaving the grid vulnerable to disruptions, particularly during periods of low hydropower generation.

Po**or Demand Forecasting and Planning**
Strategic management at ZESCO has also been criticized for poor demand forecasting and planning. Accurate forecasting is crucial for ensuring that generation capacity meets current and future demand. However, ZESCO has repeatedly underestimated domestic electricity demand, leading to situations where supply is insufficient during peak periods. This miscalculation results in unplanned load shedding as the utility struggles to balance demand with available supply (Chilufya & Mweene, 2019). Furthermore, the lack of a clear long-term strategy for demand management and energy efficiency has left ZESCO ill-prepared to cope with demand surges, particularly during extreme weather conditions or economic growth periods.

Ineffective Maintenance Practices
ZESCO's strategic management has also been flawed in terms of maintenance practices. Regular and effective maintenance of power generation and transmission infrastructure is essential for ensuring reliable electricity supply. However, ZESCO has been plagued by inadequate maintenance schedules, leading to frequent technical failures that reduce generation capacity and increase the likelihood of load shedding (Phiri, 2020). The utility's failure to implement a robust maintenance strategy reflects broader issues in its strategic management, such as a lack of focus on operational efficiency and a reactive rather than proactive approach to managing infrastructure. In defence of the utility, this problem can be attributed to lack of revenue on account of tariffs which are not cost reflective.

Weak Governance and Decision-Making

Weak governance and decision-making processes at ZESCO have further compounded the issue. Strategic decisions at ZESCO have often been influenced by political rather than economic considerations, leading to suboptimal outcomes. For instance, delays in making critical decisions regarding infrastructure projects or in adjusting tariffs to reflect the true cost of electricity production have strained ZESCO's financial resources, limiting its ability to invest in necessary upgrades and expansions (Ngoma & Sichone, 2021). This misalignment between strategic objectives and operational realities has created an environment where load shedding becomes a default response to managing the grid's limitations.It can be argued that weak governance and decision-making has made the industry oblivious to the existence of diesel power generators at Copperbelt Energy Corporation (CEC), Mopani, Konkola Copper Mines (KCM), Kasanshi and Lumwana mines with combined capacity of over 100MW which could have been utilized during the power shortages because this option beats the cost of buying new generators and shortenes the time for importing the new generators.

Addressing these strategic management failures requires a comprehensive overhaul of ZESCO's management practices. This includes implementing more accurate demand forecasting, prioritising infrastructure investments, and adopting a proactive maintenance strategy. Additionally, improving governance structures to ensure that decision-making is aligned with long-term strategic goals, rather than short-term political pressures, is crucial for reducing load shedding and improving the reliability of Zambia's electricity supply.

Cross Border Power Trading And Impact On Load Shedding

Excessive electricity exports by ZESCO, Zambia's state-owned power utility, have played a significant role in causing load shedding in the country. This situation arises when the utility prioritises export contracts over domestic supply, leading to an imbalance that impacts local electricity availability.

Imbalance Between Domestic Supply and Export Commitments

ZESCO has often overcommitted to electricity exports to neighbouring countries, even when domestic generation was under strain. This overcommitment has occurred due to contracts that often include penalties for non-compliance, which may prompt ZESCO to prioritize exports over domestic supply. As a result, when domestic consumption surges or unforeseen disruptions occur, ZESCO struggles to balance its commitments, leading to load shedding (Phiri & Banda, 2017).It is however, acknowledged that ZESCO has significantly reduced its power exports to less than 200MW.

Hydropower Dependency and Environmental Factors

Zambia's heavy reliance on hydropower exacerbates this issue. During periods of drought, when water levels in key reservoirs like the Kariba and ItezhiTezhi Dams fall, the capacity to generate electricity diminishes. Despite these conditions, ZESCO may continue to export electricity to meet contractual obligations, thereby reducing the availability of power for domestic use and leading to load shedding (Mphande, 2019).

Revenue Generation vs. Domestic Needs

Financial pressures also drive ZESCO to prioritize exports. The utility relies on export revenues to meet its financial obligations, especially during times when regional electricity prices are high. However, this focus on revenue generation can lead to domestic shortages, as seen when ZESCO continues exporting electricity despite low domestic availability (Kachingwe, 2020).

Operational and Planning Challenges

ZESCO has faced criticism for inadequate planning and forecasting of domestic electricity demand. This lack of proper assessment has led to overcommitment in exports, which in turn causes insufficient power availability for Zambian consumers. Additionally, the strain on transmission infrastructure from handling both exports and domestic distribution can exacerbate the situation, leading to inefficiencies and increased load shedding (Sakala & Ng'andu, 2021).

To mitigate these challenges, ZESCO needs to review its export agreements, ensuring flexibility to reduce export volumes during domestic shortages. Diversifying Zambia's energy mix by investing in alternative sources like solar and wind power can also reduce reliance on hydropower, lessening the impact of environmental factors. Improved demand forecasting and planning, along with strong policy and regulatory oversight, are crucial to ensuring that

domestic electricity supply is prioritized and that load shedding due to excessive exports is minimized (Lungu, 2018).

Zesco's Debt And Load Shedding

ZESCO's significant debt to Independent Power Producers (IPPs) has played a crucial role in the utility's decision to export power, which has directly contributed to load shedding in Zambia. Faced with mounting financial obligations to these IPPs, ZESCO has been under immense pressure to generate revenue. Power exports, especially to neighbouring countries where tariffs are often higher, have provided a necessary source of foreign currency. This revenue is critical for ZESCO to service its debt and maintain financial stability (Lusaka Times, 2024).

However, the decision to prioritize exports has reduced the electricity available for domestic consumption. Zambia's energy supply is already constrained due to factors like low water levels at hydroelectric dams and underinvestment in alternative energy sources. By directing a portion of the limited power supply towards exports, ZESCO has exacerbated the domestic energy shortfall, leading to increased load shedding. This situation underscores the complex balance ZESCO must strike between financial obligations and ensuring a reliable power supply for its citizens (Times of Zambia, 2024; Lusaka Times, 2024).

The strategic choice to export power as a means of debt management highlights a significant challenge in ZESCO's operational strategy. While it helps in mitigating financial pressures, it comes at the cost of energy security within Zambia, contributing to the persistent load shedding experienced by consumers.

Political Failure And Load Shedding

Political failure has significantly contributed to the ongoing issue of load shedding in Zambia, with several key aspects highlighting the impact of governance challenges on the country's energy crisis.

One major factor is the lack of effective policy implementation. Political instability and frequent changes in government have led to inconsistent energy policies and regulatory frameworks. For instance, during periods of political transition, energy projects often face delays or disruptions due to shifting priorities and a lack of continuity (World Bank, 2023). This inconsistency undermines long-term planning and investment in the energy sector, aggravating load shedding issues.

Additionally, corruption and mismanagement within political institutions have adversely affected the development and maintenance of energy infrastructure. Corruption in procurement processes and the misallocation of funds have led to suboptimal investment in critical infrastructure, including power generation and grid maintenance (Transparency International, 2022). Such practices result in inadequate infrastructure that cannot meet the growing energy demands, leading to frequent power outages and load shedding.

Another impact of political failure is the lack of coordination between various governmental and non-governmental stakeholders involved in the energy sector. Ineffective coordination and communication among different agencies often result in fragmented efforts and duplicated resources (African Development Bank, 2022). This lack of cohesion hampers the implementation of comprehensive strategies to address the energy crisis and manage load shedding effectively.

Further, political decisions regarding the energy sector are sometimes influenced by short-term electoral considerations rather than long-term sustainability. Politicians may prioritize projects that yield immediate benefits to gain voter support, rather than investing in more sustainable and potentially less popular initiatives, such as renewable energy projects (International Renewable Energy Agency, 2021). This politically correct short-sighted approach can undermine efforts to develop a resilient and diversified energy supply.

Finally, the impact of political failure extends to public trust and engagement. Eroded trust in political institutions and leaders can lead to public skepticism regarding government initiatives aimed at addressing load shedding. When citizens perceive that their leaders are not effectively managing the energy crisis, it can result in decreased public support for necessary reforms and interventions.

In summary, political failure has played a crucial role in worsening load shedding in Zambia through inconsistent policy implementation, corruption, poor coordination, short-term decision-making, and diminished public trust.

Addressing these issues requires significant reforms in governance and political accountability to create a more stable and effective framework for managing Zambia's energy sector.

Impact Of Load Shedding

Load shedding in Zambia has far-reaching social and economic consequences that significantly affect the country's development and quality of life for its citizens.

Economic Impact

Load shedding has a profound perverse impact on Zambia's economy, primarily through disruptions in industrial productivity and increased operational costs. Industries that rely heavily on a stable power supply, such as mining and manufacturing, face substantial production losses during power outages. This results in reduced output and efficiency, which can adversely affect the overall economic growth of the country (World Bank, 2023). For example, the mining sector, a major contributor to Zambia's GDP, suffers from decreased production capacity, which impacts export revenues and employment (African Development Bank, 2022).

The cost of unserved energy can be substantial for businesses, particularly in energy-intensive industries like mining and manufacturing. These sectors experience reduced production capacity during load shedding, leading to lower output and lost revenue. According to the World Bank (2023), the economic losses from load shedding in Zambia can run into billions of dollars annually. Industries forced to rely on expensive backup power solutions, such as diesel generators, face additional operational costs. This increases the cost of doing business and can erode profit margins, particularly for small and medium-sized enterprises (SMEs) (International Finance Corporation, 2022).

Quantifying the exact cost of unserved energy in Zambia involves estimating the value of lost output and productivity due to power outages. Studies and reports often use metrics such as the Value of Lost Load (VOLL), Cost of Unserved Energy (CUE) which represent the economic value of electricity that is not supplied. For Zambia, the cost of unserved energy is significant but varies depending on the severity and frequency of load shedding (African Development Bank, 2022). An attempt has been made to estimate the cost of load shedding to the economy in Zambia using the concept of the cost of unserved energy as shown in Table 1.

Table 1:- Economic Cost of Load Shedding in Zambia.

Back of Envelope Calculation of Cost of Load Shedding to Zambia's Economy	
Description	US Dollars or Energy (MWh)
Estimated GDP in 2023	US$ 76,000,000,000.00
Energy Sent Out in 2023	14, 642,222 MWh
Cost of Unserved Energy (GDP/ Energy sent out)	US$5,190.4 MWh
Estimated Power Deficit in Zambia	900 MW
Energy Deficit in one Year (900MW x 24 hours x 365 days)	7,884,000 MWh
Estimated Cost of Unserved Energy to the Economy for one year (7,884,000 MWh x US$ 5,190.4)	US$ 40,921,113.600
Percentage of Cost of Unserved Energy of Zambia's GDP	54%

The method of computing the cost of unserved energy to the economy assumes that every kilowatt-hour produced is used for production which is not the case in reality. The methodology is however, widely used to demonstrate the cost of unserved electricity (load shedding) to the economy.

Load shedding hampers economic growth by disrupting industrial activity and reducing productivity. The African Development Bank (2022) highlights that unreliable power supply can deter investment and slow economic development. Investors may be reluctant to commit to projects in regions with unstable energy supplies, leading to missed opportunities for economic expansion and job creation.

Moreover, businesses across various sectors experience increased operational costs due to the need for alternative power sources, such as diesel generators. The cost of maintaining and operating these generators can be prohibitive, especially for small and medium-sized enterprises (SMEs), thereby affecting their profitability and sustainability (International Finance Corporation, 2022). The reliance on backup power sources can contribute to inflation as businesses pass on the increased costs to consumers. Higher operational costs due to power outages lead to increased

prices for goods and services, which can reduce consumer purchasing power and affect overall economic stability (World Bank, 2023).This additional financial burden can lead to higher prices for goods and services, contributing to inflationary pressures.

Social Impact

The social impact of load shedding is equally significant. Frequent power outages disrupt daily life and affect essential services such as healthcare and education. Hospitals and clinics face challenges in maintaining critical medical equipment and providing reliable care, which can have serious consequences for patient outcomes (United Nations Development Programme, 2023). For instance, the lack of reliable electricity can hinder the operation of life-saving equipment and affect the refrigeration of medicines, potentially compromising public health.

In the education sector, power outages can disrupt teaching and learning processes, particularly in schools and universities that rely on electronic resources and digital tools. Students may experience interruptions in their studies, which can affect their academic performance and future opportunities (Zambia Ministry of Education, 2023).

Additionally, load shedding contributes to social unrest and frustration among the population. Frequent and unpredictable power outages can lead to dissatisfaction with government services and policies, eroding public trust and contributing to social instability (ZESCO, 2024). The perceived inability of authorities to address the energy crisis effectively can lead to increased public discontent and protest.

Frequent power outages can affect the quality of life for residents by disrupting daily activities and reducing access to basic services. The inconvenience and frustration caused by load shedding can lead to social unrest and dissatisfaction with government performance.

All in all, the social and economic impacts of load shedding in Zambia are extensive, affecting industrial productivity, operational costs, essential services, and overall quality of life. Addressing these impacts requires a comprehensive approach that includes improving energy infrastructure, enhancing reliability, and developing policies that mitigate the adverse effects on both the economy and society.

Managing Load Shedding

Effective management of load shedding involves several strategies aimed at minimizing its impact and maintaining grid stability:

1. **Rotational Load Shedding**: To ensure fairness and minimise disruption, utility companies often implement rotational load shedding, where power outages are distributed across different areas in a scheduled manner.
2. **Demand Response Programs**: Encouraging consumers to reduce or shift their electricity usage during peak times can alleviate pressure on the grid, reducing the need for load shedding.
3. **Real-Time Monitoring and Automation**: Advanced grid management systems that monitor electricity demand and supply in real-time can enable more precise and targeted load shedding, reducing the overall impact on consumers.
4. **Public Communication**: Clear communication with the public about load shedding schedules and the reasons behind them can help manage expectations and reduce frustration.

Prevention Of Load Shedding

Preventing the recurrence of load shedding requires both short-term and long-term measures:

1. **Increasing Generation Capacity**: Investment in new power plants, including renewable energy sources like wind, solar, and hydropower, can help meet growing electricity demand and reduce reliance on any single source of power.
2. **Improving Grid Infrastructure**: Upgrading transmission and distribution networks to handle higher loads and reduce losses can ensure more reliable delivery of electricity.
3. **Energy Efficiency Programs**: Promoting energy efficiency among consumers and businesses can reduce overall demand, particularly during peak periods, decreasing the likelihood of load shedding.
4. **Diversification of Energy Sources**: Reducing dependence on a single type of fuel or generation method by diversifying the energy mix can make the power system more resilient to disruptions.
5. **Regular Maintenance and Upgrades**: Ensuring that existing power plants and infrastructure are well-maintained and upgraded as necessary can prevent unexpected outages and reduce the need for load shedding.

6. **Policy and Regulatory Support**: Governments can play a crucial role by creating policies that encourage investment in energy infrastructure, renewable energy, and efficiency programs.

Conclusion:-

In conclusion, load shedding in Zambia represents a multifaceted challenge that extends beyond mere power shortages, impacting economic stability, industrial productivity, and everyday life (World Bank, 2023). Addressing this issue involves several critical strategic management concerns that must be tackled to achieve a sustainable resolution.

Firstly, strategic planning is essential for addressing the root causes of load shedding. This includes a comprehensive assessment of Zambia's current energy infrastructure, such as the reliability of existing power plants and the capacity of the national grid (African Development Bank, 2022). Long-term planning should prioritize investments in diversified energy sources, such as solar, wind, and biomass, to reduce dependence on hydroelectric power and mitigate the impact of climate variability (International Renewable Energy Agency, 2021).

Secondly, effective resource allocation and financial management are crucial. The Zambian government and relevant stakeholders must ensure that funds are strategically invested in both immediate solutions, such as upgrading existing infrastructure, and long-term projects, such as developing new energy generation facilities. Transparent budgeting and financial oversight will be necessary to ensure that investments yield the desired outcomes and address the energy deficit (World Bank, 2023).

Thirdly, strategic partnerships and collaboration are vital for addressing the complexities of load shedding. Public-private partnerships can play a key role in developing innovative solutions and leveraging expertise and resources from various sectors (United Nations Development Programme, 2023). The country should however, be worry of rent-seeking behaviour from private players. Engaging with international organizations and financial institutions can also provide technical support and funding opportunities (International Finance Corporation, 2022).

Additionally, risk management strategies must be implemented to address potential disruptions and ensure resilience in the energy sector. This includes developing contingency plans for power shortages, implementing preventive maintenance schedules, and improving the overall reliability of the energy supply chain (African Development Bank, 2022).

Lastly, stakeholder communication and community engagement are essential for managing the social and economic impacts of load shedding. Transparent communication about the causes of load shedding, progress in addressing the issue, and strategies for minimising its effects can help build public trust and foster cooperation among all involved parties.

In summary, addressing load shedding in Zambia requires a strategic management approach that encompasses planning, resource allocation, collaboration, risk management, and stakeholder engagement. By tackling these strategic issues, Zambia can work towards a more stable and reliable energy future, supporting economic growth and improving the quality of life for its citizens.

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