The Impact of Load Shedding on The Cost of Living: A Zambian Perspective

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***Abstract*— In this paper, we assess the impact of Zambia Electricity Supply Corporation's (ZESCO) power rationing (load shedding) on the cost of living of the Zambian people. We also assess whether the businesses and households have capacity to resort to alternative sources of energy in the time of crisis. Our results show that, although the rationing does not last for 24 hours in most places, the duration that businesses and households stay out of power is long enough to impact negatively on the livelihoods of the Zambian people and consequently it's Economy.**

***Index Terms*— Power rationing, Cost of living.**

I. INTRODUCTION

The responsibility of electricity generation, transmission and distribution in Zambia is vested in Zambia Electricity Supply Corporation (ZESCO). It was established in 1970 under the Zambia Electricity Supply Act of 1969 and operated under Zambia Industry and Mining Corporation (ZIMCO), a parastatal company formed under the companies Act. ZIMCO is no longer in existence and ZESCO now operates as a parastatal under the directive of the Government of the Republic of Zambia [1]. ZESCO was established to be responsible for the generation, transmission and distribution of electricity in Zambia.

As early as 2006, ZESCO's installed capacity was about 1631 MW against the total demand of 1200 MW. This gave the company a surplus capacity of 431 MW some of which was exported within the region [3], [4] and [6]. However, by early 2007, ZESCO's generation capacity dropped to 1000MW while demand increased to 1300 MW resulting in a shortfall of 300 MW [8].

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Like many other developing Countries, the demand for electricity in Zambia has been on the increase while power generation has remained fairly steady. This situation has resulted into electricity demand out stripping supply (shortage). Consequently, in order to cope with the crisis during peak periods, ZESCO, the major electricity power generation company in the country, resorts to power rationing.

In Lusaka, like most other places in the country, most of the electricity supplied is hydro generated and this is the major type of energy that manufacturing firms and households in the country have access to. In this regard, if ZESCO fails to produce and supply adequate electricity, and institute power rationing, businesses fail to go about their day to day operations, especially those without an alternative source of electricity [2] and [5]. This intels that, firms will most likely fail to produce the required output necessary to grow the economy and this cost of failure is transferred on to the consumers as there is a massive shortage of goods resulting into price hikes.

According to [7], Zambia is in the middle of a crippling electricity crisis as the country grapples with a 560 MW power deficit, a situation likely to only get worse as the demand for electricity grows 200 MW annually.

Government however has made strides in addressing this problem by ensuring the 120 MW Itezhi-tezi power station is commissioned, and hopefully be followed by 150 MW Maamba Coal Powered Station [8]. The latter is most likely to slip in delivery. But even if it is delivered on time, the situation is not likely to change as energy demand grows.

There are many speculations surrounding load shedding in Zambia. Some people associated it to policy makers while others feel it is a natural occurrence that will pass if the country experiences abundant rainfall over time [2] and [14]. The inadequate and untimely rainfall experienced has resulted in inadequate water flow required for generation of electricity at Zambia's biggest hydro power station (Kariba Dam).

II. THE MODEL

In order to establish the relationship between the duration of load shedding and cost of living, we also consider inflation and perform a multiple regression using the model:

Cost of living = Intercept + Coefficient (load shedding hours) + Coefficient (inflation rate) + error

Where the error is a stochastic variable accommodating any factors that may affect the cost of living other than length of load shedding hours and inflation rate. Its mean is assumed to be zero and its partial correlation with the load shedding hours and inflation rate is also zero.

We take the length of load shedding as the independent variable (X_1) and the inflation rate as (X_2). The increase in the cost of living is taken to be the dependent variable (Y).

More formally, we write;

$$\hat{y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon_i \qquad (1)$$

where:

- $\hat{y}$ is the dependent variable (increase in the cost of living per month).
- X_1 is the first independent variable (length of load shedding in hours per month).
- X_2 is the second independent variable (inflation rate per month).
- β_0, is the intercept and β_1, β_2 are the coefficients of X_1 and X_2 respectively.

III. RESULTS AND DISCUSSION

Table 2 presents the consolidated information extracted from secondary data and responses from questionnaires.

Table 2: *length of load shedding, increase in the cost of living and inflation rate*

Cost of living Per Month in Kwacha (Y)	Length of Load Shedding in Hours Per Month (X_1)	Inflation Rate in % (X2)
3793.59	5	7.7
3767.68	5	7.4
3797.55	5	7.2
3759.04	6	7.2
3677.28	6	6.9
3704.69	8	7.1
3715.47	8	7.1
3831.24	8	7.3
3957.46	8	7.7
4249.56	10	14.3
4167.7	10	19.5
4371.76	10	21.1

Tables 3 and Table 4 gives the regression output as follows:

Table* 3: Regression Statistics*

Regression Statistics	
Multiple R	0.929534331
R Square	0.864034072
Adjusted RSquare	0.833819422
Standard Error	95.63754524
Observations	12

The Multiple R of 0.93 implies a strong positive relationship between the length of load shedding hours, inflation rate and increase in cost of living. This means the longer the period of load shedding, the more the cost of living increase.

The Adjusted R Square of 0.86 is adjusted for the number of terms in the model. It is advisable to use it than the R Square since we have more than one independent variable. In this case 86% of the variations of Y-values around the mean are explained by the variations in X-values. In other words, 86% of the values fit the model. So to put it more plainly, the value 86% implies the extent to which variations in the cost of living are explained by the variations in the length of load shedding and the inflation rate per month.

The estimation of parameters is presented in **Table 4** below:

***Table* 4**: *Summary statistics of parameters*

	Coefficients	Standard Error	t Stat	P-value
Intercept	3386.03033	118.322	28.6	3.783E-10
x1	21.17092526	22.098	0.95	0.36306366
x2	35.48915922	8.377	4.23	0.00218492

The model (1) now becomes;

Cost of living = 3386.03033 + 21.17092526 (load shedding hours) + 35.48915922 (inflation rate)

That is;

$$\hat{y} = 3386.0303 + 21.17092526x_1 + 35.48915922\,x_2$$

We can now use this model to predict the cost of living. For example, load shedding lasting 15 hours at inflation rate of 23.1% is expected to result in;

$$\hat{y} = 3386.0303 + 21.17092526(15) + 35.48915922(23.1) = k4523.384757$$

We see that the longer the hours of load shedding and the higher the inflation rate, the more the cost of living increase and vice-versa. In other words, it can also be said that for each unit increase in hours load shedding, cost of living increases by 21.1709 units. For each unit increase in the rate of inflation, there is a 35.4892 unit increase in cost of living.

Now we test the significance of our model by checking only for absence of heteroskedasticity, absence of autocorrelation and linearity of the variables.

Heteroskedasticity

This occurs when variance of each of the error terms (ε_i) conditional on the values of the explanatory variable are not equal. What is required is the homogeneity of the variance of (ε_i). Symbolically, what we need is $var(\varepsilon_i) = \delta^2$.

Breusch-Pagan Test:

This test allows checking if heteroskedasticity is present in the model. It requires regressing the squared values of ε_i on the explanatory variables at 0.05 level of significance. If the siginificance F value greater than 0.05, then we conclude that heteroskedasticity is absent.

We set our hypothesis as follows:

H_0 (Null hypothesis): data is homoskedastic.

H_1 (Alternative hypothesis): data is heteroskedastic.

***Decision Rule*:**

We fail to reject the null hypothesis if significance F value is greater than 0.05.

The data used is given in **Table 5.**

Table 5: *Breusch-Pagan Test values*

ε_i^2	X_1	X_2
808.749262	5	7.7
173.5876076	5	7.4
2514.33016	5	7.2
90.97017105	6	7.2
6504.596811	6	6.9
10543.3391	8	7.1
8445.750245	8	7.1
281.2800301	8	7.3
16588.34301	8	7.7
20829.83265	10	14.3
14903.08396	10	19.5
634.997531	10	21.1

Table 6: *Breusch-Pagan Test output*

Regression Statistics	
Multiple R	0.671756
R Square	0.451256
Adjusted R Square	0.329312
Standard Error	6042.115
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Sig F*
Regression	2	270192191	135096096	3.7	0.07
Residual	9	328564362	36507151.3		
Total	11	598756553			

From the regression output in **Table 6**, the significance F value (0.07) is greater than the level of significance (0.05), this means that the coefficient is not significant, which means that we fail to reject the null hypothesis and conclude that the homoskedasticity is present.

Autocorrelation

This is the correlation between members of series of observations ordered in time. In regression context, the classical linear regression model assumes that such autocorrelation does not exist in the error terms($\hat{\varepsilon}_i$). Symbolically; $E(\varepsilon_i \varepsilon_j) = 0 \; for \; i \neq j$.

Durbin-Watson test:

This test allows checking if autocorrelation is present [10]. If the Watson d statistic is less than 2, it means there is presence of autocorrelation but if greater than 2 then autocorrelation is absent. The Watson d statistic lies between 0 and 4.

$$d = \sum_{i=2}^{n} (\hat{\varepsilon}_i - \hat{\varepsilon}_{i-1})^2 \Big/ \sum_{i=1}^{n} \hat{\varepsilon}_i^2$$

Table 7: Durbin-Watson test values

RESIDUALS$(\hat{\varepsilon}_i)^2$	RESIDUALS$(\hat{\varepsilon}_{i>1})$	$(\hat{\varepsilon}_{i-1})$	$\hat{\varepsilon}_{i>1} - \hat{\varepsilon}_{i-1}$	$(\hat{\varepsilon}_{i>1} - \hat{\varepsilon}_{i-1})^2$
808.74926	*28.43852*			
173.58761	*13.17526*	*28.43852*	*-15.2633*	*232.9669*
2514.3302	*50.1431*	*13.17526*	*36.96783*	*1366.621*
90.970171	*9.537828*	*50.1431*	*-40.6053*	*1648.788*
6504.5968	*80.65108*	*9.537828*	*71.11325*	*5057.095*
10543.339	*102.6808*	*80.65108*	*22.02968*	*485.3069*
8445.7502	*91.90076*	*102.6808*	*-10.78*	*116.2084*
281.28003	*16.77141*	*91.90076*	*-75.1294*	*5644.42*
16588.343	*128.7957*	*16.77141*	*112.0243*	*12549.45*
20829.833	*144.3254*	*128.7957*	*15.5297*	*241.1715*
14903.084	*122.0782*	*144.3254*	*-22.2473*	*494.9402*
634.99753	*25.19916*	*122.0782*	*-96.879*	*9385.547*
82318.861				***37222.52***

From the data in **Table 7**, $d = 0.4522$. Hence $d < 2$, means that there is autocorrelation present. This may have been due to the homoscedasticity of the data. We do not expect the cost of living to significantly vary among Zambians as most of the people live below the poverty line.

Linearity

This is a requirement that the response and explanatory variables need to be linearly related. Non-linearity can be detected by plotting the residuals$(\hat{\varepsilon})$ against predicted response variable. If the points are far from the horizontal zero line, then there is presence of non-linearity. But if the points are almost on the horizontal zero line, then there is a linear relationship. The data plotted is given in **Table 8**.

Table 8: Linearity values

Predicted y	*Residuals*
3765.151483	28.43851723
3754.504735	13.17526499
3747.406903	50.14309684
3768.577828	-9.537828424
3757.931081	-80.65108066
3807.370763	-102.680763
3807.370763	-91.90076302
3814.468595	16.77140513
3828.664259	128.7957414
4105.23456	144.3254401
4289.778188	-122.0781879
4346.560843	25.19915735

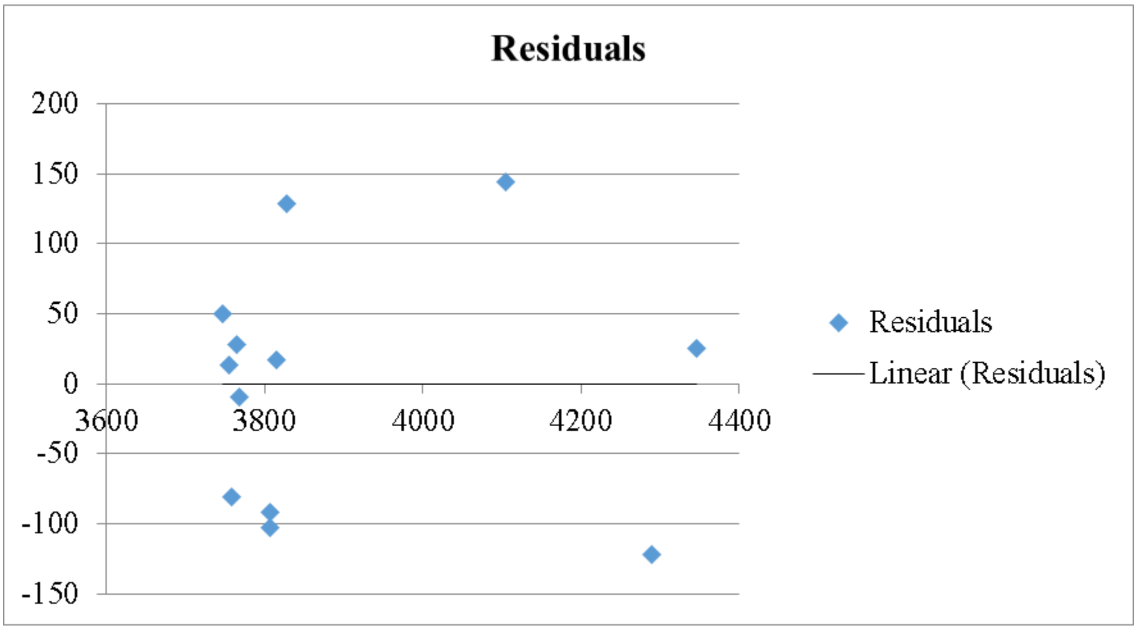

Fig 1: *Linearity output*

In **Fig 1**, it is clear that there is a linear relationship because the points are close to the zero horizontal line.

It is suffice to note that most Zambians resort to Charcoal as an alternative source of Energy as shown in **Fig 2** below:

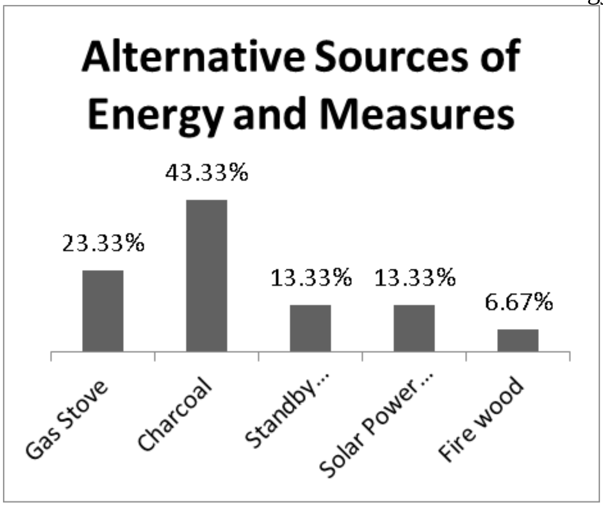

Fig 2: *Alternative Sources of Energy and Measures*

Now, policy makers should know that, as more and more people resort to Charcoal, this source of energy brings about deforestation and negative effects on the environment especially the rainfall pattern. There is therefore need for the Government to intensify sensitizations on the use of Solar Power as a vital means to curb the scourge. Our results are comparable to [9], [11], [12] and [13].

IV. Conclusion

Increased investments in electricity generation is one cost effective way of combatting power rationing in Zambia. ZESCO should not only concentrate on maintaining the current power generation infrastructure but also explore the building of new ones to increase its installed capacity and consequently the amount of power generated. We urge Government to consider opening up electricity generation to private companies and put in place legislations and mechanisms such as public private partnership that supports easy implementation of electricity generation programs. There is need for ZESCO to consider routine maintenance of equipment to enable optimal operations at all times.

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