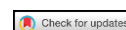






CONTRIBUTION TO THE EMPIRICS OF ELECTRICITY BLACKOUTS AND PRODUCTIVITY IN NIGERIA



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ABSTRACT

Article History

Received: 19 November 2020

Revised: 23 December 2020

Accepted: 21 January 2021

Published: 8 February 2021

Keywords

Electricity blackout
Productivity
Firms
Energy
Economic development
SMEs
FMOLS.

JEL Classification:

D24; F63; H54; K32; L94; Q4.

Purpose: The age-long problematic electricity situation and attendant loss of productive man-hour is forcing the resurgent proliferation of literature on the relationship between blackouts and productivity in developing countries. This study expands the scope of existing literature by pricing the cost of electricity blackout on productivity. **Approach/Methodology/Design:** The Fully Modified Ordinary Least Squares (FMOLS) that was developed by Phillips and Hansen (1990) was used to estimate the existing relationship. Data were sourced from the World Development Indicators, Energy Information Administration (EIA) website, the Central Bank of Nigeria (CBN) Statistical Bulletin, the Nigerian Bureau of Statistics Productivity report as well as National Electricity Regulation Commission (NERC) covering 1996-2018. **Findings:** Findings emanating from the study showed that electricity blackout has negative impact on productivity. The coefficient indicates that a one percent increase in electricity blackout will leads to a 104 percent decrease in productivity. It was equally revealed that electricity price has negative impact on productivity. Electricity generation and population have positive impact on productivity while corruption increases the influence of electricity blackout on productivity by approximately 30 percent. **Practical Implication:** The study showed that incessant electricity blackout impeded productivity which was further compounded corrupt practices in this critical sector of the economy. The paper recommends a business-friendly environment with an appropriate incentive structure that will stimulate the required development in the power sector for improved productivity.

Contribution/ Originality: This study is one of very few studies that incorporated corruption into electricity blackout modelling in Nigeria.

1. INTRODUCTION

The exact guesstimate of the associated cost pricing of electricity blackouts and voltage fluctuations on productivity remains enigmatic amidst resurgent efforts toward resuscitating the power sector in Nigeria. The state of electricity supply in Nigeria is despicable as businesses experience average power outages of 239 hours on a monthly basis, accounting for nearly seven percent of lost sales and causes economic losses in excess of US\$25 billion annually (World Bank, 2017). The precipitous downward spiral in power output in 2016 from the apex of over 5 gigawatt (GW) in March 2016 to less than 3.5 GW in early 2017 significantly resulted to the contraction of

economic activity by an projected 1.5 percent in 2016 (World Bank, 2017). Electricity blackouts reduce the level of economic activities invariably plummeting productivity.

Nigeria is currently suffering pervasive blackouts, as electricity demand surpasses supply continually (Céline, 2005; Ezennaya, Isaac, Okolie, & Ezeanyim, 2014; Imandojemu & Akinlosotu, 2018; McKinsey Global Institute, 2014; NIPP, 2018; Olayande & Rogo, 2008; Sambo, 2008). The country is acclaimed to generate one of the lowest per capita quantities of electricity in the world: At 145kWh per capita in 2014 (World Bank, 2019). At an estimated 77 million population without electricity in 2019, Nigeria lags significantly behind other developing nations in terms of electrification. Ghana's stands at 5 million estimated population without electricity, while South Africa has a meager 3 million estimated population without electricity (Central Intelligence Agency, 2020). A quantum leap in electricity output to guarantee supply for its teeming populace – nearly half of whom have no access to electricity remains a prerequisite to redirecting the development trajectory of Nigeria to the path of sustainable development.

In some countries electricity blackout is a clue to a forthcoming coup d'état. In Nigeria, it is symptomatic of continued inefficiency rather than an impending drastic change. Figuratively, "darkness" succinctly describes the electricity supply impasse in Nigeria. The entire spectrum of the power sector value chain is plagued with structural defects ranging from: energy source, electricity generation, transmission, and distribution. The operational capacity of the country's power plants is below par in comparison to global permissible threshold and currently less than a third of the installed capacity while vandals continually cripple existing infrastructure. This is compounded by visible lack of infrastructure maintenance culture which further affected the transmission grid negatively. As a final point, high collection and commercial losses have impacted the financial viability of the privatized distribution companies (Osinbajo, 2015).

According to the World Bank, an estimated 41% of Nigerian businesses self-generate power to augment the national grid supply (Nigeria Power Baseline Report, 2015). The associated costs of power outages may be direct, indirect or resulting long-term costs of macroeconomic relevance (Reichl, Schmidthaler, & Schneider, 2013). Direct costs relates to acquisition, fuelling, repair and maintenance of generators. Unreliable power supply forces industry to jettison national grid supply for off-grid alternatives which is inherently at a cost. According to (Cardinal Stone Research, 2017) indirect costs range from the inconvenience of having to reschedule activities to accommodate maintenance works to the injurious effect of generator fumes on health and quality of life and noise pollution. In addition, long-term economic effect of electricity blackouts exists. These connote economically relevant deviation in the standard behaviour of market participant resultant from electricity supply expectations. It includes potential influence on the choice of business location, expected price rise for production facilities premised on increased need for backup-systems, or customer apathy due to unreliable delivery deadlines. Consumers' willingness to pay for electricity supply is grossly affected by blackouts,

According to Aderibigbe (2010) electricity is the cornerstone on which the economy and the daily lives of Nigerians depend. Uninterrupted and energy supply improves the living conditions and welfare of the citizens substantially, facilitating the elimination of the clout of poverty that ravaged societies. In other words, a greater economic activity propelled by uninterrupted energy supply accounts for enhanced per capita income which remains a *sin-qua-non* for improved living condition. Improved living conditions is directly related to the development of economic activities through the quantitative (longer life expectancy and better health) and qualitative (better training) upgrading of the productive base. Better energy supply also opens the way to longer working hours and, where electricity is concerned, to a reduction in periods of forced inactivity resulting from power cuts (African Development Bank OECD (Organisation for Economic Co-operation and Development) Development Centre and UNDP (United Nations Development Programme), 2014). The reliance on power for increased productivity connotes that the cost implications of electricity blackout on productivity needs to be critically examined. However, difficulties arise in the exact quantification of the cost of electricity blackouts. Against this backdrop, the paper empirically examines the cost of electricity blackouts on productivity in Nigeria. The paper is organized as follows:

Section 2 summarizes conceptual issues. Available research methodology is presented in Section 3; Section 4 interprets and discusses findings from the study while Section 5 concludes with policy recommendations.

2. CONCEPTUAL ISSUES

Electricity blackout (also called a power cut, a power out, a power outage and power failure) is a severe form of power outage implying the entire loss of the electrical power network supply to consumers. Equally worrisome are blackouts that result from or result in power stations tripping, which are predominantly difficult to restore normalcy. The intensity and time spacing of power outage depends largely on the nature of the blackout and the pattern of the electrical network. Electricity blackout remain the basic problem of economic progress in less developed countries, as it is a prerequisite at both the early stages of development as well as in the permanent process of re-tooling the production apparatus of any economies. [Hunt, Allan, and Stephen \(2016\)](#) identified epileptic power supply as the major barrier to business performance, productivity and economic growth in developing countries. It restricts economic growth and development, as well as the socio-economic welfare of the people ([Musiliu & Michael, 2013](#)). Blackouts crowds out investment opportunities invariably reducing the level of productivity ([Reinikka & Svensson, 2002](#)). Sustainable increase in productivity is a *sin-qua-non* to achieving economic development and other economic objectives, which will facilitate the allocations that are not Equity as No-Envy economic benefits to the populace. The elimination of the scourge of poverty that ravaged the societies, unemployment, inequality and the sustained elevation of an entire societal system towards a better and more humane life, therefore is possible vide increase in productivity which depends largely on electricity. The lessons to be drawn from the development experience of LDCs is that national potential for development cannot be fully mobilized unless the electricity problems are sufficiently addressed to encourage people to participate fully in development. [Scott \(1985\)](#) confirmed this conjecture in the model for a low productivity trap. The significance of increased productivity caused by improved electricity supply can indeed break the vicious cycle of poverty and unemployment, and by extension dismantle the low productivity trap.

2.1. Empirical Review

The cost of an electricity outage and blackout on Nigeria's economy both at a macroeconomics or microeconomics level has been discussed over time. One of the first attempts to empirically investigate the cost of an electricity outage on Nigeria's economy is ([Adenikinju, 2005](#)). The author investigated the impact of electricity failure in developing countries with a particular focus on Nigeria. The study employed a survey method where manufacturing establishments were sampled with regards to the extent electricity supply constraints their output. It was discovered that poor electricity supply had increased the manufacturing firms' overhead cost as they often resort to self-generating electricity to cushion the effect of electricity blackout in the country. The author further discovered that small-scale enterprises are the major hit as it is often difficult for the enterprise to fund the self-electricity generation, and when they do, it usually takes a large chunk of their investment. [Tonuchi \(2019\)](#) examined the potential of renewable energy in meeting the electricity demands of rural communities in the riverine area of Niger Delta. It was discovered that conventional electricity generation through hydro-electricity is the most cost-effective, followed by electricity generation through biomass, while solar energy generation is the most expensive. The author argued that self-generating electricity through biomass is cost-effective and serves as the best alternative to the countries frequent power outages. However, the author is quick to point out that self-generating electricity is capital intensive and poses difficulties to Small scale enterprises to fund such projects.

A similar stance was shared by [Akuru and Okoro \(2014\)](#) that investigated the impact of epileptic power supply on Nigeria's economy with a focus on the performance of the SMEs. Using descriptive and exploratory analysis, the study concluded that electricity outage impacts the SMEs more severely and has contributed to the country's leading cause of SMEs failure. The study further argued that constant power failure had created an energy crisis

both within the households and Nigeria's industrial sector due to the distribution companies' inability to meet electricity demands. Still, within the microeconomic level, [Adewuyi and Emmanuel \(2018\)](#) conducted an extensive study to see if corruption plays any effective role of the relationship electricity outage on firms' performance across the six geo-political in Nigeria. The study particularly made an effort to further investigate the impact of self-electricity generation on the firm's performance across the country's geo-political zones. The study particularly used the World Bank Enterprise Survey data, ordinary least square, and Two -Stage-Least-Square techniques to estimate the relationship. It was discovered that bribery does not play any significant role in the nexus between electricity outage and firm performances across the six geo-political zones except for south-east and north-east.

The study further argued that self-generating electricity by the firms have a negative impact on their performance in three geo-political zones, including south-west, north-west, and south-south while other geo-political zone achieves positive result using self-generating electricity. However, the study failed to explain the mixed findings, while self-generating electricity should improve the firms' performances while it does not improve the performances of the firm in other zones. Are there variables the survey omitted that can explain the differences in the impact of self-generating electricity on the firm performance? A similar study was conducted by [Hunt et al. \(2016\)](#) who conducted the effect of electricity shortages on Indian manufacturing firms. The study instrumented electricity shortages using supply shifts from hydroelectric power availability. It was discovered that the electricity shortage in Indian manufacturing firms raises their average plant's revenues and producer surplus by 5 to 10 percent. The study provides significant evidence that poor electricity supply impacted the firms' capacity utilization increase their average overhead cost through rising generator cost/ self-electricity generation.

[Fisher-Vanden, Mansur, and Wang \(2015\)](#) found a similar outcome to that of [Hunt et al. \(2016\)](#) when the author investigated the impact of an electricity outage on firms productivity using descriptive survey data from China. Like most previous studies focusing on China, the study found a negative impact of electricity outage on firm's performance within the period under study. The study was silent about the role of tariffs in reducing the electricity shortage or its role in mediating the nexus between electricity outage and firm's productivity. Several other studies have equally found a negative relationship between electricity outage or blackout and firms' performance ([Abeberese, 2017](#); [Mensah, 2016](#)) or on the economy and household ([Cissokho & Seck, 2013](#); [Rud, 2012](#)).

3. RESEARCH METHODOLOGY

The research methodological framework resolves around the growth accounting model, otherwise referred to as the source of growth analysis. The origin of the growth accounting framework is traceable to the works of [Solow \(1956\)](#); [Solow \(1957\)](#); [Hayami and Vernon \(1985\)](#); [Wen \(1993\)](#). Recently, the scholarly subject has been modified and transformed by [Wang, Feng, and Xuezheng \(2009\)](#) See also [Roe, Rodney, and Choi \(2014\)](#). The growth accounting methodology dichotomized observed growth into strata. The last stratum was initially referred to as Solow's residual. It was conceptually viewed as growth attributable to technical progress which encompasses sources of growth separately from those attributable to capital and labour. Our sterling contribution of growth accounting methodology is the determination whether electricity blackout impedes or improves Nigeria's productivity. It is argued that constant electricity blackout will reduce the efficiency of factors of production particularly labour and capital. Secondly, constant blackout will raise the cost of production as firms' sources energy from other source (like self-generating electricity) that is costly and most times not environmentally friendly. The extent this constant blackout inhibit productivity particularly labour in a country has not been effectively evaluated.

[Adewuyi and Emmanuel \(2018\)](#) noted that similar to other factors of production in the production function, electricity supply is a production input that enhances production efficiency. Thus, this study following [Adewuyi and Emmanuel \(2018\)](#) fit a model as in [Equation 1](#) below:

$$\ln TFP_t = \alpha_1 \ln \text{outage}_t + \alpha_2 \ln \text{EneG}_t + \alpha_3 \ln \text{EneP}_t + \alpha_4 \ln \text{pop} + \varepsilon_t \quad (1)$$

Where the dependent variable is total factor productivity (TFP) used to capture productivity, electricity blackout (outage) is represented by Electric power transmission and distribution losses (% of output), Electricity generation (EneG), Electricity pricing (EneP), and population (pop) are all the controlled independent variables. Theoretically, a rise in electricity blackout or power outage will reduce factors of production effectiveness as bulk of the resources will lie unutilized or underutilised. In other words, a rise in power outage will lead to a fall in the productivity level of a country and this explains why most developing countries have low total factor productivity while advanced countries have high total factor productivities (Tonuchi, Idowu, Adetoba, & Mimiko, 2020). Similarly, electricity generation has a positive effect on total factor productivity, since more energy generation will mean more energy is available to be distributed to all households and firms (Tonuchi, 2019). Rise in electricity price is expected to impact productivity level of factor inputs negatively as it raises the cost of inputs. Lastly, growing population can either have a positive impact on productivity or a negative impact depending on the substitution effect between labour and capital.

We further hypothesized that the existence of corruption further intensifies the extent electricity blackout inhibits productivity across the country (Adewuyi & Emmanuel, 2018). For instance, it is believed that the existence of corruption in the electricity distribution supply chain further exacerbates the impact of blackout on productivity. For instance, electricity theft either by the distribution company staff or the public has serious negative effects on the distribution chain. These activities exacerbate power outage and ultimately compound the worrisome level of factor unproductivity. Thus, we modify Equation 1 by introducing corruption in the model as seen in Equation 2. We argue that corruption has a negative relationship with level of productivity further strengthening the level of factor unproductivity.

$$\ln TFP_{t,c} = \alpha_1 \ln \text{outage}_t + \alpha_2 \ln \text{EneG}_t + \alpha_3 \ln \text{EneP}_t + \alpha_4 \ln \text{pop}_t + \alpha_5 \ln \text{incor}_t + \varepsilon_t \quad (2)$$

Corruption perception index (Incor) from Transparency International¹ is used to proxy the prevalence of corruption in the country. We hypothesize that the rise in corruption in the country will reduce the level of productivity. Several empirical evidences revealed that economies preponderated with institutionalized corruption are characterized by low and sluggish economic development an indication of low productivity.

3.1. Estimation Technique and Procedures

The Fully Modified Ordinary Least Squares (FMOLS) developed by Phillips and Hansen (1990) will be used to estimate the existing relationship. The technique was among others developed to mitigate some structural issues with ordinary least square (OLS) particularly for estimating single cointegrating relationship in order I(1). For instance, the technique arguably performs better and more consistent compared to OLS especially in the presence of large sample bias. One common issue with OLS estimation is the bias from the estimate due to heteroscedasticity and serial correlation. This serial correlation is largely explained by the error of omission captured in the residual and ultimately affecting the true size of the standard error. Such issues can be solved by FMOLS and its counterpart dynamic OLS (DOLS) by including the leads and lags of the endogenous variables thereby solving the problem of endogeneity common in most growth related models. Rukhsana and Shahbaz (2008) noted that FMOLS is great at achieving asymptotic efficiency as it has the capacity to modify the OLS to account for serial correlation and heteroscedasticity, such that the researcher need not worry about the issue of serial correlation and heteroscedasticity in the model. One major limitation of FMOLS is that it is best suited for series with same order of integration particularly series of integrated of order one I(1). As such, the study will first establish the existence of

¹<https://www.transparency.org/en/countries/nigeria>.

stationarity among the series before the application of FMOLS to estimate the relationship between electricity blackout and factor productivity.

3.2. Data Source

Data for the study are sourced primarily from World Bank Development Indicators (WDI) 2019, the Central Bank of Nigeria (CBN) Statistical Bulletin, the Nigerian Bureau of statistics Productivity report data on electricity generation and population are sourced from WDI while data for electricity revenue is sourced from Energy Information Administration (EIA) website as well as National Electricity Regulation Commission (NERC). Following the work of Ukoima, Ekwe, Ukoima, Nkalo, and Agwu (2018) the electricity pricing is proxied by ratio of electricity revenue to the Nigeria's population. And lastly, as noted earlier, the corruption perception index developed by transparency international will be used to proxy level of corruption in the system.

4. RESULTS AND DISCUSSION

4.1. Stationarity Test

This section will present and discuss the findings of the study.

Table-1. Stationarity test using ADF statistics at trend and Intercept.

Variable	ADF @ Level	ADF @ 1 st Diff	t-Statistic	Order of integration
Lnoutage	-2.092590*	-7.054059***	-3.508508	I(1)
Lncor	-0.762839	-5.142451***	-3.508508	I(1)
LnElecP	-2.559584*	-6.166895***	-3.510740	I(1)
LnEnecG	-2.182907*	-7.054059***	-3.506374	I(1)
Lnpop	-0.309373	-4.359332***	-3.510740	I(1)
LnTFP	-2.449005*	-5.752804***	-3.508508	I(1)

Note: Significance is indicated as follows: ***, ** and * for 1%, 5% and 10% respectively.

Results from Table 1 on the ADF statistics indicates that none of the variables under investigation is stationary at level since their ADF value is less than the 5% critical value. However, after differencing the variables all became stationary at first difference. The findings above affirm the choice of FMOLS in establishing the extent electricity blackout impact on productivity. Following the example of Tonuchi et al. (2020) given that all the variables are not stationary at level and differencing the variables often leads to loss of long-run information, there is need to ascertain the existence of long-run relationship. The study starts by first applying the Eagle Granger two-step approach following Tonuchi et al. (2020). First, by estimating the relationship using OLS without including constant to ensure the variables represents deviation from their means. The next step was to subject the residual to a unit root test using Augmented Dickey Fuller. As presented in Table 2, the unit root of the residual indicates that it is stationary at level as such we conclude that using Eagle granger approach there is long-run relationship.

Table-2. ADF unit root tests result for residual (U_1).

Variable	Test Statistic	5 % critical value	Order of integration
Long (U_1)	-5.6364829**	-3.510740	I(0)

Note: Significance is indicated as follows: ***, ** and * for 1%, 5% and 10% respectively

The result is further affirmed using Johnson cointegration test as presented in Table 3 below.

Table-3. Johansen cointegration test.

Max Rank	0	1	2
Trace Statistics	125.4247**	75.4551**	41.48294
5% critical value	95.7536	69.8188	47.8561

Note: Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level

Given that the existence of long-run relationship has been validated in the model, the study proceeds to estimate the relationship using FMOLS. Both the difference version and un-difference version are estimated while the difference version is reported given that all the variables are only stationary after the first difference. However, there was no major difference in the result when it is estimated using the difference version and when it was not differenced.

Table-4. FMOLS results.

Variable	Model 1	Model 2
Lnoutage	-1.0493 (0.0024)***	-1.3113 (0.0000)***
Lncor	-	-0.4624 (0.0109)***
LnElecP	-0.3157 (0.0140)***	-0.35302 (0.0104)***
LnEnecG	0.536573 (0.0121)***	0.6923 (0.1806)
Lnpop	2.259515 (0.0052)***	0.430787 (0.0001)***
C	3.325113 (0.0274)**	2.2381 (0.0308)**
R ²	0.7710	0.7805

Note: Significance is indicated as follows: ***, ** and * for 1%, 5% and 10% respectively, p-value in parenthesis.

From the findings in Table 4, it can be revealed that electricity blackout (lnoutage) has negative impact on productivity since the p-value (0.024) is less than 5% (0.05) level of significance. The coefficient indicates that a one percent increase in electricity blackout will leads to a 104 percent decrease in productivity. The findings are consistent with the findings of Adewuyi and Emmanuel (2018). One possible explanation of the high impact of electricity blackout on productivity is the assertion made by Tonuchi (2019) when the author argued that electricity outage creates disruption in the workflow thereby reducing the productivity of the factors of production which lies idle during power outage.

It was equally revealed that electricity price has negative impact on productivity since the p-value (0.0140) is less than 5% (0.005) critical value. One possible explanation is that increase in price of electricity will raise the overhead cost of production. Similarly, increase in the cost of electricity has tendencies of reducing its demand which has capacity of affecting its usage alongside other factors. It was equally revealed that electricity generation and population has positive impact on productivity given that their respective p-value is less than 5% level of significance.

We introduce corruption in the model. In the second model when corruption was introduced it was discovered that the extent electricity blackout impacts on productivity further exacerbated as expected. For instance, the introduction of corruption in the model increases the influence of electricity blackout on productivity by approximately 30 percent. This is not abnormal given the degree corruption in the electricity distribution value chain where both the Discos staff and the public are perpetrators. Adewuyi and Emmanuel (2018) noted earlier that corruption reinforces the impact of power outage on firm performance across the six geopolitical zones in Nigeria. Again, the coefficient of the corruption indices revealed that a one percent increase in the level of corruption will leads to about 46 percent reduction in productivity.

Another noticeable fact in the model is that the introduction of corruption in the model increases the impacts of all the exogenous variables on the productivity in the country. The implication is that rising corruption incidence in Nigeria creates a structural issue since it has direct impact in almost other variables of interest. The R-square in each model is moderately high indicating that the model has a good fit.

5. CONCLUSION

The current state of affairs in the power sector points to a comparative disadvantage in overreliance on limited energy source, low technology and inefficiency. We conclude from our result that electricity blackout has negative impact on productivity which indicates that as electricity blackout increases the country stock of idle capacity. Particularly, if great number of firms are unable to access electricity through self-generating power. The

implication is that constant power outage creates disruption in the production process. Similarly, the disruption generated through electricity blackout create financial and emotional pressure on the individuals households in the form of damages to their electronic appliances which creates transfer of funds for other developmental projects to the replacement of electronics appliances damaged through frequent blackout.

We also conclude that accounting for corruption further aggravated the extent electricity blackout hinders effective productivity. We argue that accounting for corruption in the model increases the impact of electricity blackout on productivity by at least 30 percent. The implication is that if nothing is done to mitigate the high level of corruption especially in the electricity distribution value chain in the form of electricity theft by the customers and some of the discos staffs, the incidence of blackout will even worsen as the firm won't be able to accurately account for the volume of energy being consumed over time.

Similarly given that there is a negative relationship between electricity pricing and productivity, we conclude that increasing blackout of electricity will further raise the price of electricity. This will create competition for the available energy, create disruption in the distribution value chain, and lastly create hike in the cost of self-generating energy driving the price of electricity upward. The policy option will therefore be geared towards building more infrastructures in the country particularly in the value of chain of electricity distribution. While several efforts has been made to promote the development of prepaid meters to reduce the incidence of estimation disagreement between the Discos and the public, further efforts can be made to ensure effective monitoring of the distribution to reduce the incidence of electricity supply linkage through theft. One way to achieve such policies is through an enactment of law that stipulates how offenders and collaborators will be punished if caught interfering with the conventional process if such law is not available yet.

Secondly, the Discos can equally design a policy where the monitoring team for a particular location can be changed frequently as much as twice a month to reduce collaboration between the public and Discos junior staff to bypass the electricity distribution. Lastly, the electricity distribution company should be fully deregulated, and more investors should be allowed to participate in one location to create competition. Allowing one investor to control a given area will create monopoly and defeat the benefits of deregulation of the sector.

A huge natural gas deposit and the expanding global market for clean energy should provide the impetus for diversification of the energy sources. The Federal Government may leverage on Nigeria's huge renewable energy source potential and the ongoing efforts at encouraging private participation in the power sector. The ongoing steps towards private sector participation hold good potential for an additional energy source. A business-friendly environment with an appropriate incentive structure will stimulate the required development in the power sector for improved productivity. An industrialization policy with orientation towards cost efficiency should provide additional stimulus for investment in the power sector.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Acknowledgement: Both authors contributed equally to the conception and design of the study.

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