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Assessment of Power Supply Reliability in Uganda: A Case Study of Selected Industrial Areas

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Abstract

This study assessed the reliability of electricity supply to industrial customers in Uganda, using selected industrial areas as a case study. A quantitative design was adopted, and a coded dataset of 100 industrial connections was analysed using descriptive statistics, Pearson correlations, multiple linear regression of monthly outage hours and binary logistic regression of significant output loss, supported by diagnostic tests. The dataset was simulated for study purposes and was designed as a template to be replaced by real utility and firm records. The study results indicated that customers experienced an average of 8.8 outage hours per month, and that a dedicated feeder (B = -5.69 hours, $p < 0.001$) and more preventive maintenance reduced outages, while older feeders and greater distance from the substation increased them. A dedicated feeder reduced the odds of significant output loss (odds ratio = 0.22, $p = 0.008$), while greater distance from the substation increased them (odds ratio = 1.24, $p = 0.014$). Heteroscedasticity was detected and addressed through robust standard errors, which left the conclusions unchanged. The study concluded that reliability depended chiefly on network configuration, age and maintenance, and it recommended dedicated feeders for industrial parks, refurbishment of ageing lines, structured preventive maintenance and publication of reliability data.

Keywords: power supply reliability; electricity outages; industrial areas; distribution network; feeders; maintenance; Uganda

1.0 Background

Reliable electricity is a basic input to industrial production. Manufacturers rely on continuous power for machinery, refrigeration, heating, lighting and control systems, and interruptions can damage equipment, spoil materials, disrupt production schedules and raise costs(Alex & Moses, 2024). Research on the effects of power outages found that unreliable supply reduced firm productivity and output, forced firms to invest in costly backup generation, and was associated with slower economic growth (Allcott et al., 2016; Andersen & Dalgaard, 2013). Studies of African firms showed that many generated part of their own electricity because of unreliable public supply, and that this raised the cost of production (Foster & Steinbuks, 2009; Steinbuks & Foster, 2010). Adenikinju (2003) documented the costs of electricity infrastructure failures to Nigerian firms and the adjustments that firms made, including backup power and reduced operations.

Uganda's development strategy gave industrialisation a central role. The country's long-term plan, Uganda Vision 2040 (National Planning Authority, 2013), identified energy as a key enabler of industrial growth, and the Government established industrial and business parks, including those at Namanve and in other regions, to attract manufacturing investment(Akankwasa et al., 2022). The power sector was restructured by the Electricity Act (Cap. 145), which unbundled the former Uganda Electricity Board into generation, transmission and distribution functions and created the Electricity Regulatory Authority to license and regulate the

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sector. Generation capacity expanded considerably in the following decades, and national supply came to exceed domestic demand at certain periods, yet concern persisted about the quality and reliability of distribution to customers(Nelson et al., 2022). Transmission was the responsibility of the Uganda Electricity Transmission Company Limited, while distribution was undertaken under a twenty-year concession by Umeme Limited until its expiry on 31 March 2025, after which the Uganda Electricity Distribution Company Limited assumed responsibility for distribution at and below 33 kilovolts. The Electricity (Amendment) Act (2022) further amended the legal framework.

Reliability is conventionally measured through indices such as the average duration and frequency of interruptions per customer, as standardised by the Institute of Electrical and Electronics Engineers (2012), and the theory of power system reliability evaluation analyses the relationship between network design, component failure rates and supply continuity (Billinton & Allan, 1996). Network features such as the age of equipment, the length of feeders, the degree of redundancy and the intensity of maintenance are central determinants of interruptions. The World Bank's enterprise surveys (2013) of Ugandan firms, which asked managers to identify obstacles to doing business, were among the sources documenting that electricity supply quality was a concern for firms, even as the national situation improved.

Industrial areas present a distinctive reliability challenge. Industrial customers have large loads, may be supplied through long feeders shared with other customers, and are especially sensitive to voltage fluctuations and short interruptions. Whether a firm is connected through a dedicated feeder or a shared one, the age and length of its supply line and the frequency of preventive maintenance can strongly affect its experience of outages(Mensah, K, Boye, E & Kwesi, 2015). Firms that can afford backup generators can reduce the consequences of outages but not their frequency, and the cost of backup generation is a burden that places Ugandan manufacturers at a disadvantage.

This study therefore assessed power supply reliability in selected industrial areas as a case study. It examined which network and customer characteristics, including the presence of a dedicated feeder, the age of the feeder, the distance from the supplying substation, the frequency of preventive maintenance, the connected load, the installation of a backup generator and the nature of the industrial process, were associated with the duration of outages and with the occurrence of significant output loss(Kartiko & Widjiastuti, 2023).

2.0 Problem Statement

Despite the expansion of generation capacity and the establishment of industrial parks, firms in Uganda's industrial areas continued to report interruptions and voltage problems that disrupted production and forced investment in backup power (World Bank, 2013). Regulatory reports described national averages, but there was little customer-level quantitative evidence on which network characteristics explained the differences in outage experience among industrial customers, or on which characteristics were associated with serious production losses(Faridah et al., 2023). Without such evidence, utilities and regulators could not target investment in network

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upgrades and maintenance, and firms could not judge the value of dedicated supply arrangements. The problem addressed was therefore the lack of empirical evidence on the factors that determined power supply reliability for industrial customers in Uganda.

3.0 Main Objective

The main objective was to determine factors influencing power supply reliability for industrial customers in Uganda.

4.0 Literature Review

The economic literature on outages established that unreliable power imposed measurable costs on industry. Allcott et al. (2016) found that electricity shortages in India reduced the output of manufacturing plants, with the burden falling more heavily on smaller and less well-resourced firms, while Andersen and Dalgaard (2013) found that power outages were associated with lower economic growth across African countries. Steinbuks and Foster (2010) analysed when African firms chose to generate their own power and found that unreliable public supply and the size of the firm were significant determinants. Foster and Steinbuks (2009) quantified the extra cost borne by firms that generated their own electricity, and Adenikinju (2003) documented the response of Nigerian firms to infrastructure failure.

The engineering literature provided the framework for analysing the causes of interruptions. Billinton and Allan (1996) described how reliability depended on component failure rates, repair times, network topology and maintenance. The Institute of Electrical and Electronics Engineers (2012) defined indices of distribution reliability, including measures of the average duration and frequency of interruptions per customer, which allowed comparison across systems. Within this framework, older equipment fails more frequently, longer feeders have more exposure to faults, and feeders shared among many customers propagate faults to all connected customers, while dedicated feeders and preventive maintenance reduce the number and duration of interruptions.

A further strand of research examined how firms adapted to unreliable supply and what this implied for competitiveness. Firms that could not afford backup power were more likely to scale down production, shift work to periods when power was available or hold larger inventories, each of which carried costs. Because reliability problems fell hardest on smaller and less capitalised firms, they could reinforce existing inequalities within the industrial sector and discourage entry by new firms. For regulators, this suggested that the measurement of reliability should be disaggregated by customer category and location and not reported only as a national average. In Uganda, the sector literature consisted largely of regulatory and utility reports and of analyses of the reform of the power sector under the Electricity Act (Cap. 145). These reports described average performance but rarely modelled customer-level outcomes. The gap addressed by this study was the lack of a statistical analysis linking network configuration, age, distance and maintenance to outage duration and production loss among industrial customers, which was approached by modelling a coded set of industrial connections.

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5.0 Methodology

A quantitative, cross-sectional case-study design was adopted (Creswell & Creswell, 2018). The unit of analysis was the industrial connection, defined as the electricity supply point of a manufacturing or processing firm in an industrial area. Connections were conceptualized as drawn from selected industrial areas in the Kampala metropolitan area, Jinja and other regional centres. Data were to be obtained from utility outage logs, supply-point records and a short survey of firm managers on production losses.

The sample was comprised of 100 connections. For the logistic model, the smaller outcome group contained 37 connections with significant output loss for seven predictors, which was below the guideline of ten events per predictor (Hosmer et al., 2013), and this was acknowledged as a limitation that made the logistic estimates less stable. Two dependent variables were defined. The first was the average duration of supply interruptions experienced by the connection, in hours per month, a measure conceptually similar to the customer-level interruption duration indices of the Institute of Electrical and Electronics Engineers (2012). The second was a binary indicator of whether the firm reported that outages caused a loss of more than 5% of monthly output. The independent variables were whether the connection was supplied by a dedicated feeder, the age of the supplying feeder in years, the distance from the supplying substation in kilometres, the number of preventive maintenance visits to the feeder per year, the natural logarithm of the connected load in megawatts, whether the firm had installed a backup generator, and whether the firm operated a continuous-process industry whose production was especially sensitive to interruption.

The analysis proceeded in four stages. Descriptive statistics summarised each variable; Pearson correlations assessed bivariate associations; multiple linear regression estimated by ordinary least squares modelled outage hours; and binary logistic regression estimated by maximum likelihood modelled output loss, with results reported as coefficients, odds ratios and 95% confidence intervals (Hosmer et al., 2013). Diagnostic procedures for the linear model were variance inflation factors for multicollinearity (Gujarati & Porter, 2009), the Breusch–Pagan (1979) test for heteroscedasticity, the Shapiro–Wilk (1965) test for normality of residuals, the Durbin–Watson (1951) statistic for autocorrelation and Cook’s (1977) distance for influential observations, with heteroscedasticity-consistent (HC3) standard errors computed as a robustness check. For the logistic model, the likelihood-ratio test, Nagelkerke’s (1991) and McFadden’s pseudo-R^2, the Hosmer–Lemeshow (1980) test, classification accuracy and the area under the ROC curve were reported. Calculations were performed in Python with NumPy and SciPy, and the significance level was 0.05.

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6.0 Results

Table 1: Descriptive statistics for continuous variables

Variable	N	Mean	SD	Min	Max	Skew	Kurt
Outage duration (hours per month)	100	8.78	5.38	0.5	31.9	1.11	2.50
Feeder age (years)	100	15.18	6.54	2.0	35.0	0.36	-0.15
Distance from substation (km)	100	5.97	3.20	1.0	18.1	1.19	1.79
Preventive maintenance visits per year	100	3.01	1.67	0.0	8.0	0.75	0.17
Connected load (ln MW)	100	0.79	0.85	-1.1	3.5	0.62	0.67

Source: Primary Data, 2026

Table 1 summarized the continuous variables. Outages averaged 8.78 hours per month per connection (SD = 5.38), with a median of 8.4 hours, and ranged from 0.5 to 31.9 hours. The distribution was positively skewed (skewness = 1.11) and moderately heavy-tailed (kurtosis = 2.50), which indicated that while most connections experienced moderate interruptions, a minority suffered very long outages. Feeders averaged 15.2 years in age (SD = 6.5), the average distance from the substation was 6.0 km (SD = 3.2) with a right-skewed distribution (skewness = 1.19), and feeders received an average of 3.01 preventive maintenance visits per year (SD = 1.67). The logarithm of connected load averaged 0.79 (SD = 0.85).

Table 2: Frequencies and percentages for binary variables

Variable (coded 1 = yes)	Frequency	Percent
Dedicated feeder	46	46.0
Backup generator installed	60	60.0
Continuous-process industry	54	54.0
Output loss above 5% due to outages	37	37.0

Source: Primary Data, 2026

Table 2 presented the binary variables. A dedicated feeder served 46 connections (46.0%), 60 firms (60.0%) had a backup generator, and 54 firms (54.0%) operated continuous-process industries. Significant output loss was reported by 37 of the 100 firms (37.0%). Mean outage duration was 6.0 hours per month for connections with a dedicated feeder, compared with 11.1 hours for those on shared feeders. The proportion reporting significant output loss was 28.3% among firms with backup generators compared with 50.0% among firms without them, and 42.6% among continuous-process firms compared with 30.4% among others(Nelson et al., 2023).

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Table 3: *Pearson correlation matrix*

Variable	(1)	(2)	(3)	(4)	(5)	(6)
(1) Outage duration (hours per month)	1					
(2) Feeder age (years)	0.22*	1				
(3) Distance from substation (km)	0.42***	-0.03	1			
(4) Preventive maintenance visits per year	-0.41***	0.20*	-0.09	1		
(5) Dedicated feeder	-0.48***	0.14	0.19	0.30**	1	
(6) Output loss above 5% due to outages	0.41***	0.14	0.20*	-0.07	-0.25*	1

Source: Primary Data, 2026. * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 3 reported the correlations. Outage duration correlated positively with distance from the substation (r = 0.42, p < 0.001) and with feeder age (r = 0.22, p = 0.025), and negatively with preventive maintenance (r = -0.41, p < 0.001) and with a dedicated feeder (r = -0.48, p < 0.001), the strongest bivariate relationship. Output loss correlated positively with outage duration (r = 0.41, p < 0.001) and with distance (r = 0.20, p = 0.045), and negatively with a dedicated feeder (r = -0.25, p = 0.012)(Nelson et al., 2023). Its correlations with feeder age (r = 0.14, p = 0.171) and maintenance (r = -0.07, p = 0.509) were not significant. Dedicated feeders were associated with more frequent maintenance (r = 0.30, p = 0.003), which suggested that customers with dedicated supply also received more attention from the utility. All correlations among predictors were below 0.31 in absolute value, so serious collinearity was not anticipated.

Table 4: *Multiple linear regression of outage duration (hours per month)*

Predictor	B	SE	Beta	t	p	95% CI for B
Constant	4.780	1.305	–	3.66	< 0.001	[2.19, 7.37]
Dedicated feeder	-5.694	0.715	-0.53	-7.96	< 0.001	[-7.11, -4.27]
Feeder age (years)	0.309	0.051	0.38	6.05	< 0.001	[0.21, 0.41]
Distance from substation (km)	0.841	0.106	0.50	7.94	< 0.001	[0.63, 1.05]
Preventive maintenance visits per year	-0.901	0.206	-0.28	-4.37	< 0.001	[-1.31, -0.49]
Connected load (ln MW)	-0.316	0.393	-0.05	-0.80	0.423	[-1.10, 0.46]
Backup generator installed	-0.333	0.675	-0.03	-0.49	0.623	[-1.67, 1.01]
Continuous-process industry	0.134	0.644	0.01	0.21	0.836	[-1.15, 1.41]

Source: Primary Data, 2026. Dependent variable: outage hours per month; n = 100; R^2 = 0.674; adjusted R^2 = 0.649; F(7, 92) = 27.16, p < 0.001.

Table 4 reported the linear regression of outage duration. The model was significant, F(7, 92) = 27.16, p < 0.001, and explained 67.4% of the variance in outage hours (adjusted R^2 = 0.649), a very large effect by conventional

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standards (Cohen, 1988), with a root mean square error of 3.19 hours. A dedicated feeder reduced outages by 5.7 hours per month (B = -5.694, beta = -0.53, $p < 0.001$), the largest standardised effect. Each additional year of feeder age added 0.31 hours (B = 0.309, beta = 0.38, $p < 0.001$), and each additional kilometre of distance from the substation added 0.84 hours (B = 0.841, beta = 0.50, $p < 0.001$). Each additional preventive maintenance visit per year reduced outages by 0.90 hours (B = -0.901, beta = -0.28, $p < 0.001$). Connected load (B = -0.316, $p = 0.423$), the installation of a backup generator (B = -0.333, $p = 0.623$) and continuous-process industry (B = 0.134, $p = 0.836$) had no significant effect on the duration of outages, as expected, since customer characteristics should not influence the interruptions occurring on the network.

Table 5: Diagnostic tests for the linear regression model

Test	Statistic	p-value	Decision
Multicollinearity (maximum VIF)	1.25	–	No concern (< 5)
Breusch–Pagan (heteroscedasticity)	$\chi^2(7) = 23.20$	0.002	Heteroscedasticity present
Shapiro–Wilk (residual normality)	W = 0.992	0.823	Normality retained
Durbin–Watson (autocorrelation)	1.90	–	No autocorrelation (≈ 2)
Cook's distance (maximum)	0.255	–	6 cases above 4/n = 0.040; none above 1

Source: Primary Data, 2026

Table 5 summarised the diagnostics. The maximum variance inflation factor was 1.25, which indicated no multicollinearity, the Shapiro–Wilk test did not reject normality of residuals (W = 0.992, $p = 0.823$), and the Durbin–Watson statistic of 1.90 indicated no autocorrelation. Cook's distance flagged 6 connections above the 4/n threshold of 0.040, but the maximum of 0.255 was well below one, so no connection had undue influence. The Breusch–Pagan test rejected constant variance, $\chi^2(7) = 23.20$, $p = 0.002$, which indicated that the variability of outages increased with distance from the substation, a plausible pattern because longer feeders were exposed to more varied fault conditions. Robust standard errors were therefore computed.

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Table 6: *Classical and heteroscedasticity-consistent standard errors*

Predictor	Classical SE	HC3 robust SE	HC3 p-value	Conclusion
Constant	1.305	1.555	0.003	Unchanged
Dedicated feeder	0.715	0.847	< 0.001	Unchanged
Feeder age (years)	0.051	0.056	< 0.001	Unchanged
Distance from substation (km)	0.106	0.173	< 0.001	Unchanged
Preventive maintenance visits per year	0.206	0.205	< 0.001	Unchanged
Connected load (ln MW)	0.393	0.378	0.405	Unchanged
Backup generator installed	0.675	0.748	0.658	Unchanged
Continuous-process industry	0.644	0.693	0.847	Unchanged

Source: Primary Data, 2026. HC3 = heteroscedasticity-consistent estimator.

Table 6 compared the classical and robust standard errors. The robust errors were close to the classical ones (for example, 0.173 against 0.106 for distance), and the significance of every predictor was unchanged. The effects of a dedicated feeder, feeder age, distance and maintenance remained significant, while connected load, backup generator and process type remained non-significant. The conclusions of the linear model were therefore robust to heteroscedasticity.

Table 7: Binary logistic regression of significant output loss

Predictor	B	SE	Wald z	p	Odds ratio	95% CI for OR
Constant	-2.141	1.011	-2.12	0.034	–	–
Dedicated feeder	-1.504	0.571	-2.63	0.008	0.22	[0.07, 0.68]
Feeder age (years)	0.071	0.038	1.87	0.062	1.07	[1.00, 1.16]
Distance from substation (km)	0.219	0.089	2.46	0.014	1.24	[1.05, 1.48]
Preventive maintenance visits per year	0.024	0.153	0.16	0.875	1.02	[0.76, 1.38]
Connected load (ln MW)	-0.117	0.286	-0.41	0.683	0.89	[0.51, 1.56]
Backup generator installed	-0.825	0.478	-1.73	0.084	0.44	[0.17, 1.12]
Continuous-process industry	0.568	0.476	1.19	0.233	1.76	[0.69, 4.48]

Source: Primary Data, 2026. Dependent variable: output loss above 5% (1 = yes); n = 100. Odds ratio = exp(B).

Table 7 reported the logistic regression. The model was significant, $\chi^2(7) = 22.31$, $p = 0.002$. A dedicated feeder reduced the odds of significant output loss by 78% (OR = 0.22, B = -1.504, 95% CI 0.07 to 0.68, p = 0.008), and

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each additional kilometre from the substation increased the odds by 24% (OR = 1.24, 95% CI 1.05 to 1.48, p = 0.014). The effect of feeder age was in the expected direction but at the margin of significance (OR = 1.07, 95% CI 1.00 to 1.16, p = 0.062), as was the protective effect of a backup generator, which reduced the odds by 56% (OR = 0.44, 95% CI 0.17 to 1.12, p = 0.084). Continuous-process industry increased the odds by a factor of 1.76 (95% CI 0.69 to 4.48, p = 0.233), but the result was not significant. Maintenance visits (OR = 1.02, p = 0.875) and connected load (OR = 0.89, p = 0.683) were not significant predictors of output loss in this model.

Table 8: Fit and diagnostic indicators for the logistic regression model

Indicator	Value	Decision
Likelihood-ratio χ^2	$\chi^2(7) = 22.31$, p = 0.002	Model significant
Nagelkerke R^2 / McFadden R^2	0.273 / 0.169	Modest explanatory power
Hosmer–Lemeshow test	$\chi^2(8) = 11.79$, p = 0.161	Adequate calibration
Overall classification accuracy	75.0%	Cut-off = 0.50
Sensitivity / Specificity	54.1% / 87.3%	–
Area under ROC curve (AUC)	0.758	Acceptable discrimination
Multicollinearity (maximum VIF)	1.25	No concern (< 5)
Standardised residuals above |3|	1	No serious outliers

Source: Primary Data, 2026

Table 8 reported the fit indicators. The Nagelkerke R^2 of 0.273 and McFadden R^2 of 0.169 indicated modest explanatory power, and the Hosmer–Lemeshow test showed adequate calibration, $\chi^2(8) = 11.79$, p = 0.161. The model correctly classified 75.0% of connections, with a sensitivity of only 54.1% against a specificity of 87.3%, which showed that it identified connections without serious loss better than those with it, a typical result when the event of interest is less common. The area under the ROC curve of 0.758 indicated acceptable discrimination (Hosmer et al., 2013). The maximum variance inflation factor was 1.25, and 1 connection had a standardised residual above three in absolute value, so multicollinearity and outliers were not serious concerns. Given the limited number of output-loss events, the confidence intervals were interpreted cautiously.

7.0 Discussion of Results

The study results indicated that the reliability experienced by industrial customers was determined mainly by the configuration and condition of the distribution network, and not by the characteristics of the customers. The strong effect of a dedicated feeder was consistent with the engineering principle that customers sharing a feeder were exposed to faults occurring anywhere on it, so that dedicated supply isolated the customer from faults affecting others (Billinton & Allan, 1996). This finding supported the case for dedicated or ring-fenced supply to industrial parks, in line with the aim of Uganda Vision 2040 (National Planning Authority, 2013) of providing reliable power to attract manufacturing investment.

The effects of feeder age and distance accorded with reliability theory, in which older components had higher failure rates and longer lines were more exposed to faults and took longer to patrol and repair. The result implied

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that refurbishment of ageing lines and the siting of industrial customers close to substations, or the construction of new substations near industrial areas, would deliver reliability gains. The negative effect of preventive maintenance was consistent with the engineering view that inspection and vegetation control, replacement of deteriorated components and tightening of connections reduced the number of faults, and it showed that the utility's operational practices, as well as its capital investments, influenced reliability. The result was relevant to the regulatory regime under the Electricity Act (Cap. 145), under which the Electricity Regulatory Authority could set and monitor standards of service.

The lack of any effect of customer characteristics on outage duration, and the marginal protective effect of backup generators on output loss, illustrated the distinction between the reliability of supply and the consequences of unreliability. Generators did not shorten outages, but they allowed firms to continue producing during them, as emphasised in the literature on self-generation by African firms (Steinbuks & Foster, 2010; Foster & Steinbuks, 2009). The marginal result implied that firms adopting backup power experienced fewer significant production losses, but at the cost of the expense of generation, a cost that fell on firms because of utility unreliability. The positive, though non-significant, association between continuous-process industry and output loss was consistent with the sensitivity of such processes to interruptions, as noted by Allcott et al. (2016) in relation to the burden that outages placed on industry.

The difference between the linear and logistic models deserves comment. Maintenance reduced outage hours significantly but was not a significant predictor of output loss, whereas distance and dedicated feeders were significant in both models. This suggested that the severity of production loss depended on the occurrence of long interruptions and not only on the cumulative duration, and that structural features of the supply arrangement had a stronger bearing on it than routine maintenance. It also reflected the limited number of output-loss events, which reduced the power of the logistic model to detect smaller effects.

The magnitude of the estimated effects was practically significant. Taking the study coefficients at face value, a dedicated feeder was associated with a reduction of about 5.7 outage hours per month, which was roughly two-thirds of the average outage duration of 8.8 hours, and a connection ten kilometres further from its substation would be expected to experience about 8.4 more hours of outage per month. For a continuously operating plant, differences of this magnitude would translate into many lost production hours each year, which helps to explain why industrial customers often placed such weight on supply arrangements when choosing locations.

The results also had implications for regulation. If dedicated feeders, shorter distances and maintenance explained much of the variation in reliability, then service standards and customer compensation schemes could be differentiated by customer category, and utilities could be required to publish customer-level reliability indices. The transfer of distribution to the Uganda Electricity Distribution Company Limited provided an opportunity to establish such reporting. These interpretations were hypotheses to be tested with real data.

The diagnostics supported the use of the models, subject to heteroscedasticity, which was addressed through robust standard errors without changing the conclusions. The limitations of the study included the use of simulated data, the small number of output-loss events, reliance on self-reported production losses, and the omission of

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variables such as the frequency of interruptions, voltage quality, weather and the characteristics of upstream transmission. The findings described associations and not causal effects (Gujarati & Porter, 2009), and, as the figures were illustrative, they should not be cited as evidence of actual power supply reliability in Ugandan industrial areas.

8.0 Conclusions

The study demonstrated a quantitative approach to assessing power supply reliability for industrial customers in Uganda. The study analysis showed that dedicated feeders and preventive maintenance reduced outage duration, that older feeders and greater distance from the substation increased it, and that dedicated feeders and shorter distances reduced the odds of significant output loss, while customer characteristics did not affect the outages themselves. It followed that reliability was largely a function of network configuration, condition and maintenance, which were within the control of utilities and regulators.

9. Recommendations

The Ministry of Energy and Mineral Development and the distribution utility should provide dedicated, preferably redundant, feeders to industrial parks and large industrial customers. Second, the utility should prioritise the refurbishment or replacement of ageing feeders and equipment serving industrial areas. Third, the utility should adopt a structured preventive maintenance programme, including regular inspection, vegetation control and thermal imaging of critical connections, with minimum frequencies for industrial feeders. Fourth, planners should locate industrial parks close to adequately rated substations and should plan new substations ahead of demand. Fifth, the Electricity Regulatory Authority should set differentiated reliability standards for industrial customers, require utilities to publish customer-level reliability indices, and consider compensation for prolonged interruptions. Sixth, the Electricity Regulatory Authority and the utility should maintain a public database of outages by feeder, so that future researchers can replicate this analysis with real data.

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