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Correlation between Load Growth and Reliability of an Electric Service Cooperative in the Philippines

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Abstract *— This study determined the relationship between the load growth and the reliability of an Electric Service Cooperative (ESC) in the Philippines. Statistical research design and documentary analysis were utilized in this research.*

It was found out that over a period of five years, the demand and energy consumption of the whole franchise area of the respondent ESC power distribution utility has grown significantly. Also, this study disproves that load growth may lead to the overloading distribution lines and equipment and thus, causes power interruptions .Furthermore, demand and energy consumption is not correlated with the frequency and duration of power interruptions. Moreover, this study also revealed that the reliability of the respondent Distribution Utility (DU) does not vary for the period of 5 years.

It is recommended that there should be the right way of clearing activities and line rehabilitations should be doneto have a more efficient transfer of energy and to improve the DU's reliability.

Keywords *— **Electrical Engineering, electricity, power distribution, power interruption, reliability.***

I. INTRODUCTION

Republic Act No. 9136(2001) stated that the electric power industry in the Philippines should be composed of four (4) sectors, namely: Generation, Transmission Distribution and Supply. Generation Sector is where electricity or electric power is made. Transmission Sector provides the bulk transfer of electrical power from generation plants to distribution utilities. A Distribution Utility (DU), is any Electric Cooperative, Private Corporation, Government-Owned and Controlled Corporation or Local Government Unit for whom has exclusive franchise rights for a particular area to operate an Electric Power Distribution System [1]. The Electric Power Distribution System refers tothe system of wires and associated facilities belonging to a Distribution Utility, extending between the delivery points on the transmission, sub-transmission system, or generating plant connection and the point of connection to the premises of the End-User or a Consumer [2]. Distribution Utilities are the ones in-charge of distributing power to the residential, commercial, institutional and industrial consumers. The scope of work of the DUs involves the construction, operation and maintenance of power substations and distribution lines, installation and maintenance of distribution transformers and metering equipment and ensuring the delivery of safe, reliable and cost-effective electric power to the end-users.

Load Growth or the increase of demand for electric power and energy consumption is the most significant factor in the management of a distribution system. Forecasting the increase of Energy Consumption and Demand is essential for planning the maintenance, operation and expansion of the distribution facility [3].

The Philippine Distribution Code(2016) defined Reliability as "the probability that a system or component will perform a required task or mission for a specified time in a specified environment. A power system can continuously provide service to its customers." Reliability is basically the ability of any power system to withstand power interruption.

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Reliability is measured in four (4) Indexes namely, (a) System Average Interruption Frequency Index (SAIFI) which indicates how often the average customer experiences a sustained power interruption over a predefined period of time; (b) System Average Interruption Duration Index (SAIDI) indicates the total duration of interruption for the average customer during a predefined period of time. It is commonly measured in customer minutes or customer hours of interruption; (c) Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service; and (d) Momentary Average Interruption Frequency Index (MAIFI) which indicates the average frequency of momentary interruptions [1].

With all these, this study was conducted to investigate the relationship between Load Growth and System Reliability. The data gathered came from the actual monthly engineering report submitted by the respondent DU to the National Electrification Administration from January 2013 up to December 2017.

II. METHODOLOGY

Statistical research design such as correlational research and documentary analysis were utilized for the purpose of this study. Correlational research, according to [4] as cited in [5] and [6], "is employed to test the degree of relationship between two variables". On the other hand,"document analysis is a form of qualitative research in which documents are interpreted by the researcher to give voice and meaning around an assessment topic" [7]. In this study, the documents analyzed were the Monthly Engineering Report of the Distribution Utility that wassubmitted to the National Electrification Administration from the period of 2013 to 2017. The particular data that were observed were the Monthly Peak Demand, Energy Consumption, SAIFI, SAIDI and MAIFI.

To obtain statistical evidence about Variation on the Demand, Energy Consumption, SAIFI, SAIDI and MAIFI, the data were subjected to the One-way or One Factor ANOVA (analysis of variance), while the correlation on the data of demand and Energy Consumption and SAIFI, SAIDI and MAIFI, Pearson's r was used.

III. RESULTS AND DISCUSSION

Demand: Using One-way or One Factor ANOVA (analysis of variance), at 5% level of significance, the critical value of F-ratio is 2.53. The calculated value of F-ratio is 26.46. Therefore, the Null Hypothesis is rejected meaning that there is a significant variation in the data from 2013 to 2017. By observation of the annual mean, we can say that there is an increase in Demand. The mean annual demand for 2013 and 2017 are 13.833 Megawatts and 20.575 Megawatts respectively. The annual mean of demand is shown below in Table 1.

Table 1. The Annual Mean Values

	2013	2014	2015	2016	2017
Demand	13.833	15.253	16.982	19.214	20.575
Energy	6107300	6585759	7204230	8218767	8621702
SAIFI	0.990	1.416	1.451	1.023	0.971
SAIDI	26.736	46.093	40.349	55.309	39.648
MAIFI	4.941	4.732	4.732	4.380	4.876

Energy Consumption: Using One-way or One Factor ANOVA (analysis of variance), at 5% level of significance, the critical value of F-ratio is 2.53. The calculated value of F-ratio is 9.99. Therefore, the Null Hypothesis is rejected meaning that there is a significant variation in the data of Energy Consumption from 2013 to 2017. By observation of the annual mean, we can say that there is an increase in Energy Consumption. The mean of the annual Energy Consumption for 2013 and 2017 are 6,107,300 kilowatt-hours and 8,621,702 kilowatt-hours respectively. The annual mean energy consumption is shown below in Table 1.

SAIFI: Using One-way or One Factor ANOVA (analysis of variance), at 5% level of significance, the critical value of F-ratio is 2.53. The calculated value of F-ratio is 0.35. Therefore, the Null Hypothesis is accepted meaning that there is no significant variation in the data of SAIFI from 2013 to 2017. This shows that the frequency of power interruptions have not significantly changed over the years. The mean annual SAIFI for 2013 and 2017 are 0.990 and 0.971 respectively. The annual mean energy consumption is shown below in Table 1.

SAIDI: Using One-way or One Factor ANOVA (analysis of variance), at 5% level of significance, the critical value of F-ratio is 2.53. The calculated value of F-ratio is 0.13. Therefore, the Null Hypothesis is accepted meaning that there is no significant variation in the data of SAIDI from 2013 to 2017. This shows that the duration of power

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interruptions have not significantly changed over the years. The mean annual SAIDI for 2013 and 2017 are 26.736 and 39.648 respectively. The annual mean of energy consumption is shown below in Table 1.

MAIFI: Using One-way or One Factor ANOVA (analysis of variance), at 5% level of significance, the critical value of F-ratio is 2.53. The calculated value of F-ratio is 0.02. Therefore, the Null Hypothesis is accepted meaning that there is no significant variation in the data of MAIFI from 2013 to 2017. This shows that the frequency of momentary power interruptions has not significantly changed over the years. The mean annual MAIFI for 2013 and 2017 are 4.941 and 4.876 respectively. The annual mean of energy consumption is shown below in Table 1.

Correlation of Energy and Consumption to SAIFI SAIDI and MAIFI: Calculating for the Pearson r Correlation Coefficient of the Demand to SAIFI, SAIDI, MAIFI and Energy to SAIFI, SAIDI and MAIFI, the result is shown in Table 2.

Table 2. Results of the Calculation of the Pearson's r Correlation Coefficient

Demand to SAIFI	0.05
Demand to SAIDI	0.16
Demand to MAIFI	0.06
Energy to SAIFI	0.04
Energy to SAIDI	0.10
Energy to MAIFI	0.05

Based on the calculated value of the Pearson's r coefficient, there is a negligible correlation between the Demand and Energy Consumption to SAIFI, SAIDI and MAIFI.

IV. CONCLUSIONS AND RECOMMENDATIONS

The authors hereby conclude that for this particular Distribution Utility, the Power Demand and Energy Consumption has grown significantly over the years relative to the growth of population and the growth on the number of households. However, the frequency and duration of power interruptions are not correlated with the growth on Demand and Energy Consumption disproving the assumption that in a distribution system, higher load causes equipment to fail and hereby causes power interruptions. To improve power system reliability, the distribution must enhance the capability of the distribution network by rehabilitating lines and doing right of way clearing activities so that power interruptions may be minimized.

Likewise, a direct and simple [8] research on the same discipline with more distribution utility respondents should be to conducted be able to make accurate decisions given much available data or information [9] to further validate the findings of this study.

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