Comparative Load Flow Analysis of Overhead and Underground Cable System on Baidam Feeder

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***Abstract*—Distribution of electric power is the final stage to deliver electric power to end users. It carries required voltage level of electric power from the distribution substation to individual consumers. Baidam feeder from Kudhar substation, Pokhara Nepal, is 11 kV domestic and commercial feeders which is of straight run length of 9.07 km consisting of 77 distribution transformers. Load flow analysis of this feeder is performed in Electric Transient Analyzer Program (ETAP) software. After replacement of overhead line by underground cable beyond Jarebar in Lakeside area active power loss, reactive power loss and voltage drop is reduced by 71.6 kW, 68.5 kvar and 2.79% respectively. Reliability assessment of underground system shows decrease in System Average Interruption Frequency Index (SAIFI) and increase in System Average Interruption Duration Index (SAIDI). The peak load of the feeder is forecasted to be double in fiscal year 2088/89.**

Keywords— Distribution system, Feeder, Load flow, Reliability indices, Load Forecast

I. INTRODUCTION

Distribution is the electrical system between the distribution substation and the consumer's meters. It is the part of the power system which distributes electric power for end use. In Nepal almost all the feeder are radial type feeder. Alternatively distribution system can be categorized in two ways: Overhead and Underground distribution system. The underground cables have several advantages over overhead line. Underground cable have smaller voltage drop and are less affected or damaged though lightning, requires less maintenance cost and have less chance of fault. Underground cables provide better general appearance & most reliable system. In a modern power system for power distribution, generally underground cables are used. Recent improvement in design and manufacturing made it possible to employ underground cables even for high voltage transmission of electric power for short or moderate distance. [1]

Reliability of a power distribution system can be defined as the ability to deliver uninterrupted service to customer. In order to reflect the reliability of individual customers, feeders and system oriented indices related to substation, distribution system reliability indices can be presented in many ways.[2] Load forecasting technique is used by energy providing companies to predict the energy needed to meet the demand and supply equilibrium. Load forecasting helps an electric utility in many aspects. It helps to make important decisions including decisions on purchasing and generating electric power, load switching, and infrastructure development. Load forecasting can be generally done by trend analysis, End use model and Economic model. [3]

Among the different tourist destination of Pokhara, Nepal, Lakeside is one of the important destination. Baidam feeder from Kudhar Substation, Pokhara, runs to Lakeside. Baidam feeder is choosed for the underground analysis regarding improvement of its aesthetic beauty. Baidam feeder is domestic and commercial feeder which is of straight run length of 9.07 Km. Considering the total branches of the feeder, the length is 21.29 Km. Number of transformer used is 77. Otter conductor is used for length up to 4.06km from Kudhar substation. For all other main line run and branches, Rabbit conductor is used i.e. the length of rabbit conductor is 17.23 Km.

The main objective of this paper is to analyses the load flow of existing overhead distribution system of Baidam feeder and to perform the feasibility analysis of underground cable system of Lakeside area in same distribution system using ETAP software. This paper

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also analyses the reliability indices of distribution system.

II. METHODOLOGY

A. *Data Collection and field survey*

Among 77 distribution transformer of Baidam feeder, there are 35 private transformers and 42 utility transformers. Peak load data of Baidam feeder for last eight years is tabulated in table I.

TABLE I. ANNUAL PEAK LOAD DATA

FY	Maximum current (A)	Peak Load (MW)	Load Shedding
66-67	325	5.263	Yes
67-68	333	5.393	Yes
68-69	339	5.493	Yes
69-70	347	5.62	Yes
70-71	379	6.138	Yes
71-72	430	6.964	Yes
72-73	433	7.012	Yes
73-74	395	6.397	No

Popular GPS app, OSMTracker for Android (v0.6 11) is used for obtaining the exact GPS coordinate of distribution transformer following the distribution line route. Figure 1 show the Google earth view of distribution line and transformers.

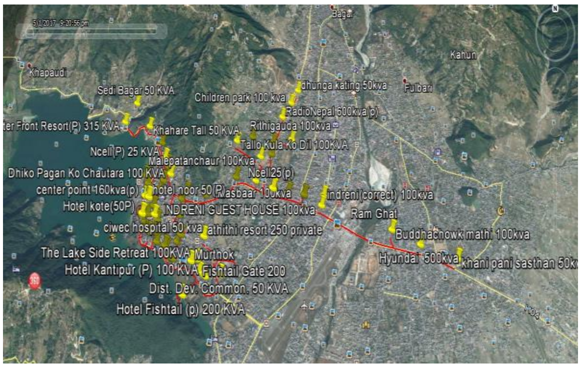

Fig. 1. Google earth view with transformer location.

B. *Simulation*

ETAP software (v12.6.0) is used for load flow the simulation of existing distribution system of Baidam feeder with data of FY 2073/74. Similarly another load flow simulation is done with replacement of overhead line by underground cable beyond Jarebar using data of FY 2073/74. A sectionalized view of the ETAP simulation is shown in figure 2.

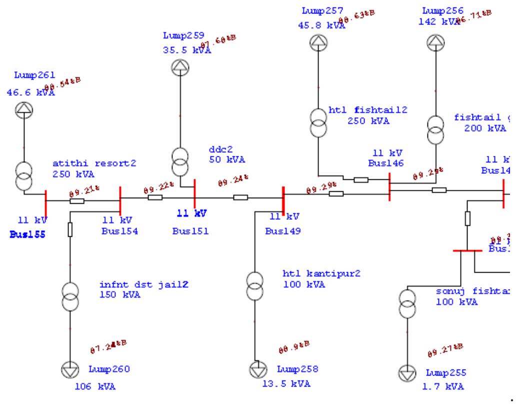

Fig. 2. Sectionalized view of single line diagram of Baidam feeder.

C. *Load Forecasting*

Trend analysis is adopted for long term load forecasting. Variation of peak load during load shedding and without load shedding period is considered to forecast the load for upcoming 15 years with a method, giving rise to least mean absolute percentage error (MAPE).[4][5]

III. RESULT AND ANALYSIS

The load flow simulation result of the existing system for FY 2073/74 shows the total active power loss of 860 kW which is 13.45%, reactive power loss of 1073.9 kvar and voltage drop of 20.75%.

Similarly load flow simulation using underground cable beyond Jarebar shows the total active power loss of 788.6 kW which is 12.32%, total reactive power loss of 1005.4kvar and voltage drop of 17.96%.

The analysis of result shows the reduction in active power loss by 71.6 i.e 1.13%. For an equivalent power transmission, underground cable offers lower resistance which in turn reduces active power losses. Average reduction on power loss is found to be 19.18 kW for load factor of 0.441 [6] and loss of load factor of 0.268. The average annual energy saving is found to be 168094 kWhr.

On account of less spacing between the conductors the cables have much capacitance, so draw higher charging current. Thus the line capacitance compensates the reactive power demand and hence reactive power demand decreases. Figure 3 and figure 4 shows the comparison of active power loss, reactive power loss and voltage drop of existing and underground cable system respectively.

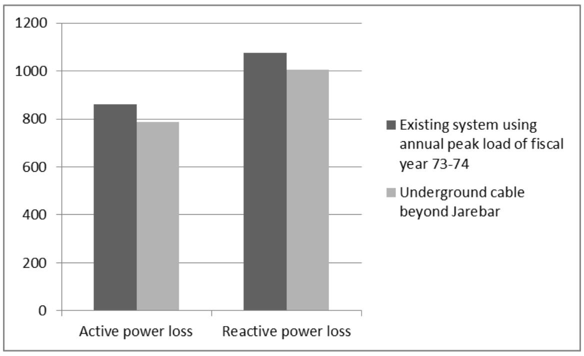

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Fig. 3. Comaparision of losses

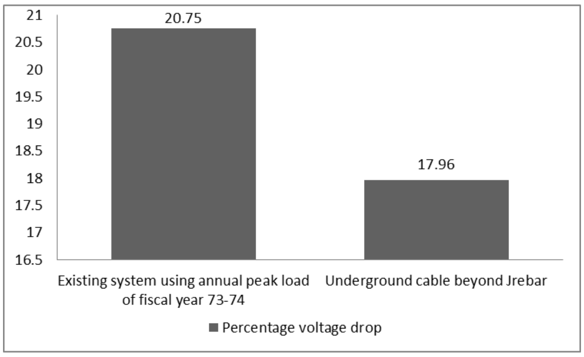

Fig. 4. Comparision of Voltage drop.

The liner model of load forecasting give rise to equation (1) with the MAPE of 6.54%.

$$Y=4.022+0.2803x$$

Where y=Forecasted peak load without load shedding and x=number of years after the base FY 2066/67. The exponential method give rise to equation (2) with the MAPE of 3.31%.

$$Y=4.136exp(0.0526x)$$

Forecasted load upto FY 2089-90 using exponential model is shown in figure 5. Thus if peak load continues to increases in this similar trend, present system can't handle its load reliably after 2079/80.

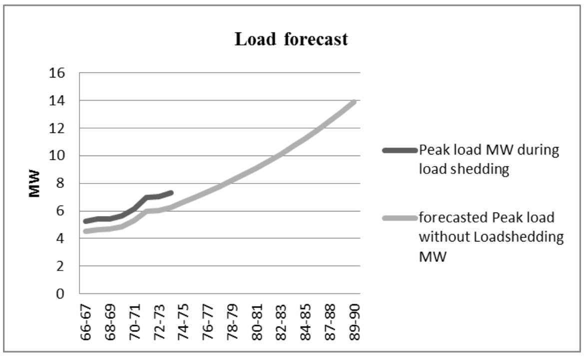

Fig. 5. Forecasted load

Reliability assessment of existing overhead system shows the System Average Interruption Frequency Index (SAIFI) of 4.90 f/Customer, year and System Average Interruption Duration Index (SAIDI) of 320.83 hr/Customer, year. Similarly the reliability assessment of after underground cable system beyond Jarebar shows the SAIFI of 4.45 f/Customer, year and SAIDI of 322.30 hr/Customer, year. After analyzing these values we found SAIFI is less for underground system than for overhead system. This is because in underground system all the equipment's and cables are buried under ground and provided with proper protection and insulation, hence less chance of fault and failure. So, the rate of interruption of supply in underground system is less. But SAIDI is greater for underground system because if any fault occurs, it is difficult to locate and hence takes more time to repair.

IV. Conclusion

In compare with overhead system, in underground system peak active power loss is reduced by 71.6 kW, with an annual average energy saving of 168094 kWh. Reactive power loss is also reduced by 68.5 kVar. Similarly the voltage drop is reduced by 2.21%. Load forecasting shows the peak load will double at 2088/89. The research shows that, current 11 kV system is capable to carry power economically up to the forecasted load of 2079/80. Reliability assessment shows the decrease in rate of interruption per consumer per year but increase in interruption duration due to difficulty in fault location in underground cable system.

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