Pilot Project On Implementation Of GSM and GPRS Based Smart Metering System For Electrical Utilities At Phuentsholing Region

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ABSTRACT

Smart metering has become a necessity in this modern world. Everything is getting digital and electronics communication is fast conquering the world. Smart metering has various benefits, reading meter remotely which is a primary function, data analysis and many more. Electrical energy has become an expensive commodity; therefore efforts must be made to minimize its use and use if efficiently. Smart metering provides this opportunity. Bhutan Power Corporation is the only utility company in Bhutan which distributes electricity in Bhutan. The Corporation aims to replace conventional metering techniques with smart meters by the use of Automatic Meter Readers (AMR). The introduction of this new technology requires huge investment and proper planning. This paper focuses on detailed study on smart metering and its data analysis, along with Cost Benefit Analysis and the feasibility of the project, a case study for an Industrial Estate based in Pasakha, Phuentsholing.

Key words:- *Smart Metering, AMRS, Electrical Energy, Cost Benefit Analysis.*

1. INTRODUCTION

Electrical energy is the main source of energy in Bhutan that is responsible for smooth operation and sustainability of any industry in Bhutan and 88 % of lighting is done by electricity. DGPC is solely responsible for generating power and Bhutan Power Corporation Limited (BPCL) for transmission and distribution of power. Bhutan Power Corporation Limited (BPCL) was launched as a public utility on the 1st of July 2002 with the mandate of distributing electricity throughout the Country and also providing transmission access for generating stations for domestic supply as well as export. BPC's basic mandate is to ensure electricity is available to all, make sure that it is reliable, adequate, fair and above all within the means of all consumers.

Smart metering is new technology to BPC and to the Bhutanese but it has been proven very vital and essential in developed and also developing countries due to cost savings it provides and other benefits. BPC has three different LV, MV and HV users, of which MV and HV users contributes bulk of BPCs income.

Smart metering is achieved by using AMR meters, where meters are read remotely, readings transmitted through modem to the central station or the billing unit of the utility. Smart meter provides accurate and correct bills compared to the manual readings where readings are error prone. The meters can also detect tamper events and notify the customer through SMS services.

Different analysis like demand side management, maximum demand, voltage stability analysis are performed using the AMR meter data. Cost benefit analysis provides basis for taking decisions for implementing different projects. The issues with the stand alone meter is that it is highly person dependent and readings are error prone, billing requires excessive time, meter data can only be used for billing purpose not for any other purpose like load forecasting, voltage stability, load survey and demand management.

2. LITERATURE REVIEW

Ashna K and George N S (2013) described the current system of energy metering in India, the meters used are either electronic or electromechanical meters are used. This system requires meter readers to visit the meter site physically to bill, and it records only kWh (Energy).

3. METHDOLOGY

Literature review on the smart metering or AMR network architecture is done to study the components of smart metering and its pros and cons. Along with that the software associated with it, Integrator the server based software and M-Cubed software which is used for viewing meter data.

Pasakha Industrial estate and Chilouney Village was chosen as our area of interest because College of Science and Technology is located just 10 km away from the Pasakha Industrial estate. Besides that many MV and HV customers including industries are located in the same place, making our visit to the sites more comfortable and fruitful. The E3MO25, 3 phase, 4 wire is the specification of the energy meter used under the research and modem i ECD 210 both MS Secure Make.

Based on the reading obtained from the M-cubed software, we have done analysis such as Voltage Stability, Demand Side Management, Load Forecasting and Maximum Demand. Apart from the analysis cost benefit analysis both for MV and LV customer is presented. Load forecasting and demand side management are done considering the previous load or history data. Voltage stability is analyzed using graphical analysis. In this paper benefits and costs are considered in terms of monetary value and unemployment issue as a result of smart metering is not considered. The benefits and costs are then quantified using relevant data and analysis techniques. A comparative analysis is presented both in graphical and tabular format. Simple payback period and net present value are evaluated for the period of five years for MV/HV group and checked the feasibility of the project.

4. DISCUSSIONS

4.1 Demand Side Management & Load Forecasting

Demand side management is important in the power system to maintain the balance between supply and demand. The two most commonly used demand side management methods are energy efficiency and demand response. Energy efficiency programs include permanent changes on equipment (e.g., exchanging an inefficient ventilation system with a better one) or improvements on the physical properties of the system (e.g., investing in the building shell by adding additional insulation. Energy efficiency involve energy audits, efficiency standards for buildings, use of energy-efficient equipment and fittings, weatherization of homes and education campaign.

Demand response, on the other hand relies on financial signals as main incentives for altering patterns of consumer electricity usage. These financial signals come in the form of incentives (e.g. reductions for voluntarily reducing the power consumption during periods of particularly high demand) or penalties (e.g. encountering excessive charges per kWh during periods of peak usage). Demand response involves load management and curtailment, the use of incentives and price signals to enable customers to adjust their consumption pattern, such as shifting energy use to off peak hours to reduce electricity costs.

a) Pricing Program

Time of Use; One day is divided into block of hours and tariff differs from block to block but not within the block. The traffic is highest for the on peak block and lowest for the off peak block. Looking into the consumption pattern and load curve, tariff can be divided in to three parts. The on peak time with highest tariff,, mid peak with tariff between on peak and off peak and off peak with lowest tariff. The table below shows the proposed different block of hour in a day (Shown in Table 1).

b) Critical Peak Pricing

This approach is very similar to TOU except that it is applied relatively to small "event days". The "event days" are advertise by utility company in advance based on their forecast of a high demand. The ratio of on peak to off peak price is higher in CPP event days than TOU program. The same structure can applied to event on every day.

Table 1 Different block of hours in a day.

Sl.no.	Time	Tariff
1	1:00:4:00 AM	Off peak
2	4:00:800 AM	Off peak
3	8:00:1200 AM	On peak
4	1:00:4:00 PM	On peak
5	4:00:8:00 PM	On peak
6	8:00:12:00 Mid night	Mid peak

c) Load forecasting

Electricity as a product has different characteristics compared to other market product. This is because energy cannot be stored for future use. The energy is generated as soon as it is demanded. The main objectives is to provide the end user the safe and stable electricity. Therefore, electric power load forecasting is important process in the planning of the electric industry and operation of the power system [16]. Here the load data of different days, week or months are compared and forecast the load.

Exponential Smoothing formula is given by

$$F_2 = F_1,$$

$$F_3 = a * Y_2 + (1 - a) + F_2$$

Where Y is the previous demand and the F is the forecasted load [17].

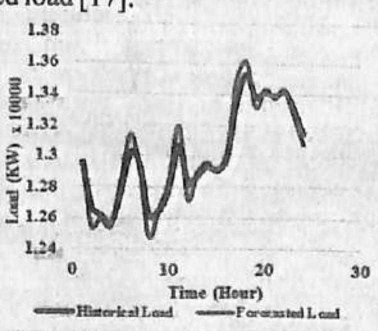

Fig. 1 Forecasted Load at $a = 0.7$

4.2 Maximum Demand

Most of the MV and HV customers like mini and large industries are paying extra charge for the reserved contract demand even though they consume less power and paying penalty if the consumed power exceeds the contract demand.

A case study was done to study the impact of maximum demand in one of the industries in Pasakha, Phuentsholing, Bhutan. The contract demand was 13 MW whereas the industry never crossed 12 MW mark from the data collected. If the contract demand is reduced to 12 MW the saving for the company will be 1 MW. Also at the same time utility company can supply the extra 1 MW to other sectors. Following Graph shows the annual maximum demand of the industry.

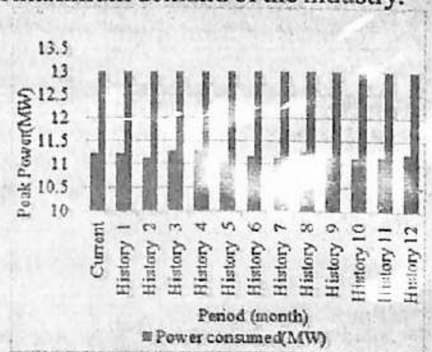

Fig. 2 Peak Power and Contract Demand

4.3 Voltage Stability

Voltage stability of system is a voltage that can recover back to stable or normal position after disturbances. Voltage is said to be in stable conditions if it varies within the defined limit of ± 10 % of system voltage. The problem of voltages instability arises due insufficient or ineffective reactive power management. Voltage stability is required for proper operation and functioning of electrical power equipment's, it prevents from damages such as overheating of generators and motors. Good Voltage profile also reduces losses and it facilitates the system to withstand disturbances and prevent voltage collapse.

From AMR data voltage readings can be obtained for every 30 minutes, these data are plotted in graphs and checked for variations and voltage stability.

In this case, there is dynamic variation of R-phase voltage which determines fluctuation in varying system loads. From 19:00pm to 20:00pm variations of voltage falls below the -5% from the defined limits of voltage stability. It indicates there is unbalance in the system loads.

The practical importance of voltage stability analysis is that it helps in designing and selecting counter measures which will avoid voltage collapse and enhance stability. The driving force for voltage instability is usually the loads. In response to a disturbance, power consumed by the loads tends to be restored by the action of motor slip adjustment, distribution voltage regulators, and tap changing transformer.

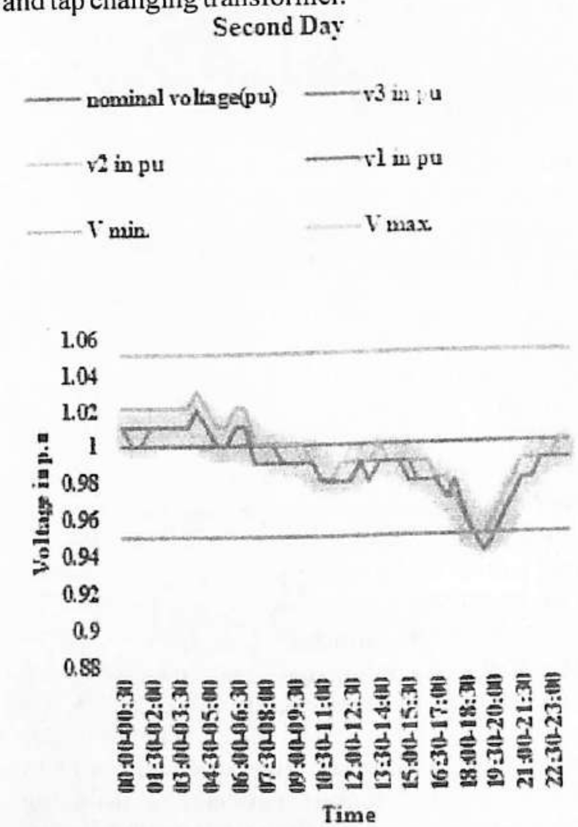

Fig. 3 Three phase voltage variations

Therefore, the control of voltage levels is accomplished by controlling the production, absorption and flow of reactive power at all levels in a system. Reactive power compensation is often most effective way to improve voltage stability. The control of voltage levels is accomplished by controlling the production, absorption and flow of reactive power.

4.4 Cost Benefit Analysis

Cost Benefit analysis is a method of organizing information to aid decision making of any project; it checks the viability of the project weighs advantages and disadvantages and provides a base for taking decisions. It provides quantitative comparisons of options together with any information that cannot be quantified to aid in decision making.

- Some of the Parameters used are:-
- Simple Payback period
- Net Present Value (for five Years)
- Inflation rate (8.27 % as of 2015, NSB)
- Incremental effect(2.5 % BPC regulation)

a) Simple Payback and Net present Value

The simple payback period is evaluated and NPV for a period of five years based on the current costs and inflation rate and the no of employees was considered three based on the project site. The simple payback period was found to be 4.41 years with a NPV of Nu 44710.89 for 16 customers considered, discounted at 4 % annually with inflation of 8.27 percent.

Table 2 Costs and Benefits HV& MV

Sl No	Cost (Nu)	Benefits (Nu)	Remarks
1	2164800	-	Cost of modem and Software
2	-	40875.00	Salary of employee including TADA & Fuel Cost(Exclusive of maintenance cost)
Note:- Accessories cost of Nu 48000 is included in Costs, TADA Nu 250/day, salary @ Nu13000/month. Fuel @ Nu 50/lit (diesel).			

For LV user groups the payback period is 3.76 years. The payback period of LV user group is less than that of MV and HV groups since the meter reader considered is three for MV and HV groups and four for LV group. The result would be 5.56 years if the three readers were considered. The result would change for large number of customers in case of LV, the whole Phuentsholing ESD has around 8000 customers and about 100 meter readers then the payback period would be about 65 years.

Table 3 NPV table for MV/HV Group

Year	Benefits (Nu) per Year	NPV (Nu)	Remarks
1	472500	44,710.89	A cost of Nu 2164800 was considered for calculating NPV.
2	484572.15		
3	496967.5768		
4	509696.1382		
5	522767.7853		
Total	2486503.65		

The project is viable since NPV is positive; more over the lifespan of smart meter and its accessories is 10 years, therefore after five years all the cost would have been recovered. In th same manner the NPV for LV users were found to be Nu 227485.99.

b) Incremental Factors

The incremental factors are considered at incremental percentage of 1 percent, benefits and NPV are computed. These results are presented in graphical forms.

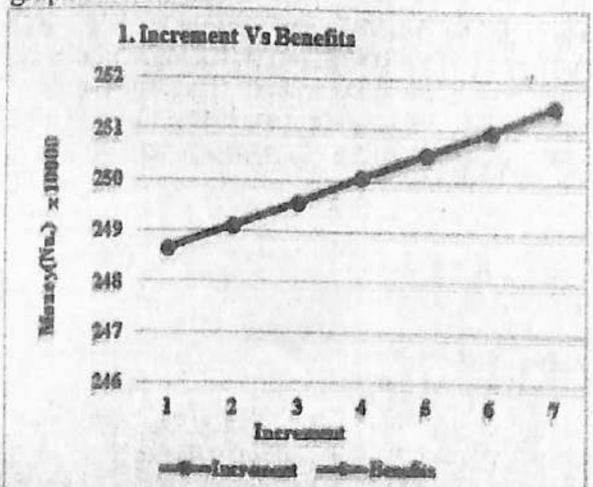

Fig. 4 Graph showing Increment vs Benefits

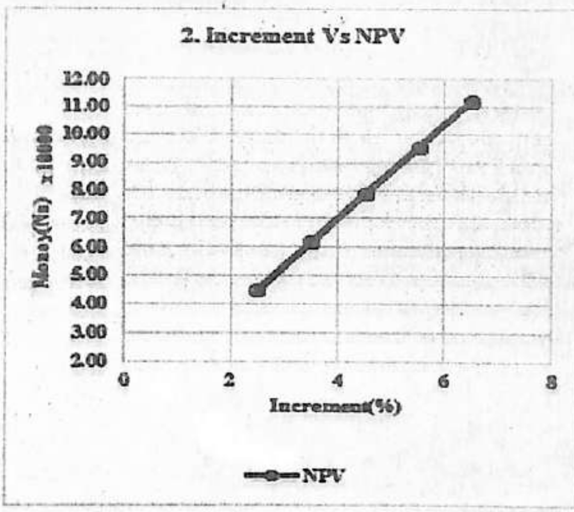

Fig. 5 Graph Showing Increment vs NPV

From the above graphs it is clear that as incremental changes occur the benefits and NPV increases proportionately. Salaries of the employees are considered as benefits because by the use of smart meters, meter readers will not be needed.

c) Inflation Rate

The annual inflation rate for the last one decade was obtained from National Statistical Bureau published annual reports. The Average inflation was found to be 6.55 % while in the last five years the inflation rate was 8.018 %. The trend from the graph shows that the inflation in the country is increasing every year. This also affects the projects feasibility, although minimal effect is observed both in terms of benefits and NPV.

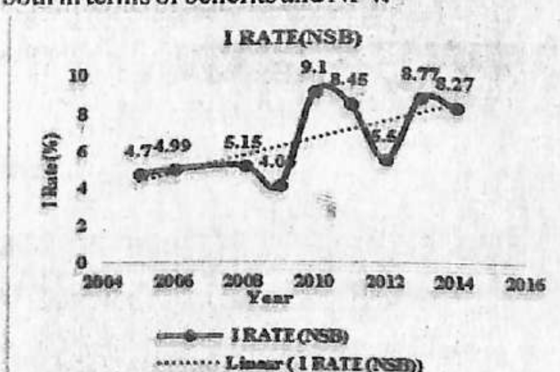

Fig. 6 Graph Showing Inflation rate over last one decade

Table 4 Benefits, NPV and Inflation Rates

Year	I Rate (%)	Benefits (Nu)	NPV (Nu)
2015	8.27	2,209,510.88	44,710.88
Average	6.5533	2,208,739.73	43,939.73
5 years	8.018	2,209,397.43	44,597.43
Approx.	13	2,211,742.65	46,942.65

Note: - The inflation is considered for cost of fuel only as salary is incremented @ 2.5 % without considering pay hike in five years.

d) Cost Escalation (%)

Cost escalation occurs in any project due to inflation and also economy conditions. Therefore the table and graph below shows how it affects the NPV.

Table 5 Table showing NPV for different I rates

Sl No	Cost Esc. %	NPV (Nu)	Remarks
1	1%	23062.89	Discount rate of 4 % annually was used.
2	2%	1414.89	
3	3%	-20233.11	

e) Sensitivity analysis for LV customers

The benefit and NPV was found to have positive effect for incremental increase and inflation. The cost escalation study was also done, with increase in cost escalation the NPV decreased. If the cost increased beyond 10 percent the project is not viable for the selected site, i.e. Chilouney Village. Following Table shows it.

Table 6 Cost Escalation (LV Group)

Sl No	Cost Esc. %	NPV(NU)
1	1	270835.79
2	2	243728.7
3	3	216621.79
4	10	26872.79
5	11	-234.21

f) Feasibility Analysis

The result a) & b) shows that the project is feasible with a payback period of 4.41 years. The actual life span of meters and modems and other accessories are 10 years, therefore the project is viable. The NPV considering the inflation rate @ 8.27 % and increment of 2.5 % on salary is positive for five years; from this we can conclude financially this project is viable. Result c) shows the sensitivity of the project to different inflation rates, the table shows that NPV increases as inflation increases as cost of fuel depends upon the inflation rate. Cost escalation of the project shows that if the project cost escalates beyond 3 % the project is not viable.

5. LIMITATIONS

Load forecasting done is based on previous data, without considering climatic factors; therefore errors might be present in the forecasted load. The cost benefit analysis does not cover the employees who will be losing their jobs and their compensation to be paid which comes at a cost.

This paper can be used as a reference to forecast industrial loads, study of voltage profile and also to compute cost benefit analysis and compare feasibility of the project.

6. CONCLUSIONS

Although the advent of smart metering involves cost, with the globalization and rapid development of e-metering all over the world, Bhutan should also develop along with it. From the above cost benefit analysis it can be concluded that smart metering technology is feasible, there is a positive NPV and payback period is also within five years. The lifespan of the meters and other accessories are said to be ten years, therefore the project is feasible.

Demand Side Management can be performed using AMR meters, which in near future will be a very important element power system network in Bhutan. Load Forecasting can also be done, in this report short term load forecasting is done, since data recorded was for a year only. Maximum Demand study pointed out that some of the Industries have high contract demands; if the contract demand is reduced considerable savings is possible. Voltage Stability is one important parameter to be considered in any Power System Network, therefore with the help of smart meters voltage stability study is done.

Smart metering is inevitable; time has come for Bhutan and BPC in particular to move for e-metering and billing system. Following are some of the future scope and research areas:-

The Analysis on Load Forecasting is done based on previous data, by looking at the trend and pattern of load, MATLAB Simulink can be used to study about the load forecasting by taking environmental factors into considerations besides the electrical load, model it and forecast the load. The forecasted load will be much more accurate and precise.

Cost benefit analysis done is much more concentrated on quantity; actual scenario of unemployment is not considered. The discount rate taken is internationally accepted value, the real value might be different, maintenance costs of vehicles, testing and commissioning charges, social impacts both positive and negative are not considered.

Smart Metering using AMI system that is Advanced Metering Infrastructure can be explored.

Nevertheless the drive for smart metering technology is fast growing and with the advancement of technology, Bhutan must also go for smart technologies no matter what the cost for efficient and effective service.

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