Strategical Application of Scada in Feeder 2 of an Electric Utility

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***Abstract*—The evaluation of the study is based on metering system and controls of distribution utility overcurrent protective device such as reclosers were taken to account in order to meet the goals for the installation of components of the Supervisory Control and Data Acquisition (SCADA) system. Value and calculation are culminated in order to ascertain the economic feasibility of the proposed project. For an effective system analysis of the substation, factors such as an hour work reduction, lesser repetition of work, and sufficient time to time date were assessed. Possible future upgrades were recommended to improve the power system. Other methods of research such as descriptive, creative, and prognostic are used, so that the proponents will be able to analyze the present system. The study is based on its technical, specification and operational feasibility to help analyze the cost and calculation of the proposed project.**

***Indexed Terms*—SCADA; feeder; electric utility; metering system; control**

I. INTRODUCTION

Man's obsession for convenience has driven him to invent devices that will help him manage the daily drudgeries of life. Central to this is the reliance in electricity [1].

Electricity is now considered as vital to human existence as water, as evidence by our heavy dependence on it. This prompted the establishment of power plants all over the world. Furthermore, innumerable studies on energy sources, its efficient use and creative ways to harness it emerged. In order to address this problem, electric power utilities worldwide are increasingly adopting the computer aided monitoring, controlling and managing of electric power distribution system to provide better services to consumers. [2]. As the technology is advancing, the monitoring of electricity has been made easier because of SCADA [3].

A SCADA System usually consists of the following subsystems: the master station, remote terminal units, communication system, control devices and measuring devices [4]. For electric utility, a SCADA provides three functions in operation, Data Acquisition, Supervisory Control and Alarm Display [5].

- Brief History of Electric Utility in Pampanga

It was December, year 1972, EPECO (Eastern Pampanga Electric Cooperative) was born followed by SEPECO (South Eastern Electric Cooperative) and then transformed to PELCO (Pampanga Electric Cooperative)

On April 8, 1979, PELCO was divided into two though an agreement made in the Yearly Conventional Meeting at Sto. Domingo, Mexico, Pampanga.

PELCO II was created by means of Presidential Decree 269 and was registered under the leadership of the Guagua Substation. It was consist of two Power Transformer; the first one has a capacity of 10 MVA and composed of two feeders supplying the area of Sasmuan, Bacolor, Guagua, and the nearest part of Lubao. While the other one has a capacity of 15 MVA and also compose of five feeders supplying the area of GRES, the Sta Rita and some part of Bacolor. The area covered by PELCO II are the towns of Bacolor, Guagua, Sasmuan, Sta. Rita, Porac and Mabalacat. The total number of member consumers at that time was 28,696.

Electric power monitoring and reading is one of the major requirements to run an electric cooperative. Some electric cooperatives in the country today had experienced the need to upgrade electric power monitoring and data gathering to prepare for possible power failure. One concept of this problem is to upgrade the system by automated electric power monitoring and data acquisition [6].

This study can create an appropriate solution for the consumer of Guagua substation because it can make things easier and faster human errors can be eliminated through the proposed system [7]. The study will determine if the application of the SCADA system is appropriate to PELCO II in Guagua substation especially to its monitoring and metering system.

Once automated, it is expected that the company will have a control on the distribution operation. Metering system will be more accurate and more reliable, thus minimizing the problems in electrical distribution leading to better services [8]. Both PELCO II and its consumer will buy from the system. The study leads to the modernization of the distribution system of PELCO II. Also, it can surpass in many ways the capabilities of the existing system in accomplishing the distribution of electricity [9].

This study is conducted to examine the possibility of integrating a SCADA to Guagua Substation of PELCO II. It will focus on small scale SCADA system and the benefits of application of SCADA in power monitoring and controlling, particularly on switching of breakers of the substation [10]. The study will be limited to the technical aspect of the automated design, specifically on the control, monitoring and installation. It will not cover the grounding, communication system and computer related aspects of the project.

II. METHODOLOGY

For the fulfillment of the objectives of this study, the group decided to use SCADA as advanced technology that aims to address the problems that the researchers have uncovered in the present system adopted by Guagua substation.

In order to gather enough information, the proponents chose to use various data gathering methods of research such as library research, interviews, and field research.

Likewise, the researchers used the internet and library to gather data on the use of SCADA to have a concrete knowledge about it.

III. RESULTS & DISCUSSION

Comparison of the existing system and the proposed system:

The manual operation of the Guagua substation is not totally utilized. There are several problems that are encountered which are unavoidable such as power restoration and unexpected electrical faults. When these problems are present in the existing system it takes time and energy to locate the electrical fault that makes the restoration of the service delayed. Some of which are only located by manual checking of the personnel that is on duty or by the consumers that are affected by the power failure.

In this scheme it is much better to provide high quality power control. By the use of advanced technology, it can now easily monitor the electricity. The SCADA was designed to monitor and control a power system. SCADA is a computer aided monitoring system and because of this it can easily monitor a distribution system. By applying SCADA this will become easier to locate the necessary information than the manual operation. Through automatic report, it reduces the number of man-hours required for operating the system. It can help for future upgrades of the system. The proposed system is consisting of an audible and visual alarm that will call the attention of the personnel when a certain electrical problem occurs. In the existing system data gathering in the substation is scheduled twice a week while in the proposed, it is real time to time gathering because of the RTU device. The control system of the existing system uses manual controllers and in the proposed it is remote controlled. In the monitoring aspect, the proposed system uses a computer aided monitoring that function as the master station that will indicate directly in the problem while the existing is a manual indication or often is the indicator lights in the controls in the substation.

The expenses of the utility are consist of Man-Power Php per month 9,000,000, Components Cost per year of 120, 055,000 Php, Rental Cost per month of 17,000 Php for wide sub-offices and 8,000Php for typical sub-offices, lastly is the Transportation Cost. Transportation Cost is consisting of 8 vehicles for the 8 departments and 4 vehicles per sub-offices. Each of the vehicles has expenses of 600 Php per day. The total expense of electric utility per year in Php is 251,275,000. By the average earnings of utility from yearly the total earnings of utility in Php is 10,139,749.6 per year without SCADA.

By the proposed system the Man power reduction is analyzed. From the 4 tenders it will now become to 2, each tenders had a salary of 20,000 per month. In the end of a year the savings of the cooperative in Php is 520,000. From this the cooperative will have average earnings of Php 10,659,749.6.

The yearly energy sales of the utility: in the year 2017 – 147,475, 093.02 Php, 2018 – 115,339,169.74 Php, 2019 – 110,067,835.90Php, 2020 – 111,219, 289.69 Php and a total of l – 484,101,388.35 Php. The average amount of energy sales is

= Total amount in 4 years / 4
= 484,101,388.35 / 4
= 121,025,347.1 Php

Average Earnings of utility per Year
= Average Amount (year) x 18%
= 1,452,304,165 x 0.18
= 261,414,749.6 Php

The yearly expenses of Utility are,
Man-Power (incentives and bonus included):
= 9,000,000 Php/month x 13 month/year
= 117,000,000 Php/year
Average Components Cost = 120,055,000 Php/year

Transportation Cost:
12 Sub-offices
8 Departments
4 Vehicles per Sub-Office
1 Vehicle per Department
Expenses per vehicle per day = 600 Php
In a year of operation there is 360 days.

Total Vehicle
= (no. of Sub-offices) x (no. of vehicle per Sub-office) + (no. of Departments) x (no. of vehicle per Department)
= (12 Sub-offices) x (4 vehicle per Sub-offices) + (8 Departments) x (1 vehicle per Department)
=48 vehicles + 8 vehicles
= 56 vehicles

Average Transportation Cost per Year
= (Total no. of Vehicle) x (Expenses per vehicle per day) x 360 Days
= (56) x (600 Php) x 360
= 12,096,000 Php

Rental Expenses (Year)
9 wide Sub-offices
3 typical Sub-offices
17,000 Php per wide sub-offices per month
8,000 Php per typical sub-offices per month

Cost Average (typical sub-offices) per year
= (no. of typical sub-office)x(cost per month)x 12 months
= (3 sub-offices) x (8,000php) x 12 months
= 288,000 Php

Cost Average (wide sub-offices) per year
= (no. of wide sub-office) x (cost per month)x12
= (9 sub-offices) x (17,000php) x 12 months
= 1,836,000 Php

Total Rental Expenses
= Cost Average (wide sub-offices) per year + Cost Average (typical sub-offices) per year
= 1,836,000 Php + 288,000 Php = 2,214,000 Php

Total Expenses per Year
= Man Power + Transportation Cost + Average Components Cost + Rental Expenses per Year
= 117,000,000 + 12,096,000 + 120,055,000 + 2,214,000

= 251,275,000 Php

Total Earnings of utility per Year
= Average Earnings of utility per Year – Total

Expenses per Year
= 261,414,479.6 – 251,275,000
= 10,139,749.6 Php

Equipment Cost
The proposed system has consisted of the equipment's which are Nexus 1250 (RTU), Display Monitor, Shielded Wire (RJ-11), Computer, I/o Modules, Interposing Relay and SCADA software, the cost and quantity of each component are referred in Table 1.

Table 1: SCADA Equipments

Equipment	Quantity	Cost (Php)	Total (Php)
Nexus 1250 Remote Terminal Unit	7	160,000	1,120,000
Display Monitor Nexus P40N	7	35,000	245,000
Shielded wire RJ-11	3km	20 Php/m	60,000
Computer set1Gb RAM, 80 Gb Hard disc Drive, Pentium Core Duo, w/printer	3	30,000	90,000
2 Meg I/O Module 8A14 8 analog outputs	1	80,000	80,000
Interposing Relay (omron 8G3NA)	7	25,000	175,000
SCADA Software (Communicator EXT 3.0)	1	300,000	300,000
Total	**2,070,000**		

Labor Cost in Php
Labor Cost = Equipment Cost x 15%
= 2,070,000 x 0.15
= 310, 500 Php
Training Cost in Php
= 300,000 Php
Transportation in Php
= 50,000 Php
Total Expenses of SCADA (Php) or Cost of Investment
= Equipment cost + Labor Cost + Training Cost + Transportation Cost
= 2,070,000 + 310,000 + 300,000 + 50,000
= 2,730,500 Php

Computation of system (SCADA Installed)

The former four workers that monitor the substation or tenders, was now proposed to two people. Where in the wage of every tender, every month is 20,000 Php.

So, the total wage per year of the two tender is,

Wage Total = (Wages/month) x (Number of Tenders) x (13Months)
= (20,000 Php/month) (2 Tender) (13 month/year)
= 520,000 Php/year

The new cost now for man power per year is the difference between the total man power and the total wage per year of the two tenders. That is,
Man-Power = 117,000,000 Php/year – 520,000 Php/year
= 116,480,000 Php/year

Transportation Cost= 12,096,000 Php
Average Components Cost = 120,055,000 Php/year

Rental Expenses per Year = 2,214,000 Php

Total Expenses per Year
= Man Power + Transportation Cost + Average Components Cost + Rental Expenses Per Year
= 116,480,000 + 12,096,000 + 120,055,000 + 2,214,000
= 250,775,000 Php

Total Earnings of PELCO II per Year

= Average Earnings of PELCO II (year) – Total Expenses per Year

= 261,414,479.6 – 250,775, 000

= 10,659,749.6 Php

Table 2: Comparison of Earnings

Scenario	Average Earnings per year (php)	Expenses per year (Php)	Total Earning per year (Php)
Existing	261,414,749.6	251,275,000	10,139,749.6
Proposed	261,414,749.6	250,755,000	10,659,749.6
Savings			**520,000**

R.O.I = Cost of Investment / Savings

= 2,730,500 / 520,000

= 5.25 years

Table 3: Comparison of Components

Criteria	Existing System	Proposed System
Alarm System	None	Audible and visual Alarm
Data Acquisition	Scheduled (Twice a week)	Real time to time gathering (RTU)
Control	Manual (Controller see figure 17)	Remote Controlled (RTU, Remote Terminal Unit, Nexus 1250)
Monitoring	Manual (Indicator Lights)	Computer aided monitoring (Computer, Master Station)

CONCLUSION

After all the study done the present system, this project would benefit the company by providing an automated system as well as an improve service. The cost of this project was justified by the persons that the researchers interviewed. Based on the economic advices and analysis, there was a big possibility of applying SCADA to Guagua substation and it would be considered a first step for the modernization of PELCO II. The materials of SCADA system are on hand available. In fact, there are many company dealers and suppliers of the SCADA system that would be easily accessible. Finally, the application of SCADA is a good project due to economical and engineering feasibility. Through SCADA the operation of the system is enhanced. The proposed system is more efficient in generating presentable and accurate information. Likewise, the proponents concluded that the proposed system is ready for implementation because of its technical and operational feasibility.

RECOMMENDATION

SCADA system are used for fault identification and breaker control, feeder switching, reconfiguration, load management, automated meter reading (AMR), archiving process and dispatch accuracy feedback.

For the next researchers, a thorough analysis to analyze this study is recommended though an expansion of the whole coverage of the SCADA from a single substation to the whole coverage of PELCO II. The advanced use of SCADA communication like wireless and fiber optics can also be applied for better SCADA application and operation. It recommends installing RTU per Pole of each feeder. For the maintenance of the SCADA, comparing the previous application with the present situation and the future application may be considered for more reliable result.

REFERENCES

[1] C. A. Awosope, Nigerian Electricity Industry: Issues, Challenges and Solution, Covenant University 38th Public Lecture,Ota, Nigeria, 2014.

[2] Saru Sehgal, Vikas Acharya, "Effect of PLC and SCADA in boosting the working of elevator system", 2014 IEEE Students' Conference on Electrical, Electronics and Computer Science, pp.1-6, 2014.

[3] Rajeev Kumar, M. L. Dewal and Kalpana Saini, "Utility of SCADA in power generation and distribution system," 2010 3rd International Conference on Computer Science and Information Technology, Chengdu, China, 2010, pp. 648-652, doi: 10.1109/ICCSIT.2010.5564689.

[4] David Bailey and Edwin Wright, Practical SCADA for Industry, McGraw-Hill Company, United States of America 2003

[5] Donald G. Fink and Wayne Beaty, Standard Handbook of Electrical Engineers, McGraw-Hill Company, United States of America, 2000

[6] Alcayde, A.; Robalo, I.; Montoya, F.G.; Manzano-Agugliaro, F. SCADA System for Online Electrical Engineering Education. Inventions 2022, 7, 115. https://doi.org/10.3390/inventions7040115

[7] A. Garc´ıa-Dom´ınguez, "Enabling SCADA cluster and cloud for smart grid using hierarchical multicast; the PTMF framework," in Proceedings of the IEEE International Conference on Industrial Technology, vol. 2015, pp. 218–225, Seville, Spain, June 2015.

[8] H. H. Safa, D. M. Souran, M. Ghasempour, and A. Khazaee, "Cyber security of smart grid and SCADA systems, threats and risks," in Proceedings of the CIRED Workshop 2016, pp. 1–4, Helsinki, Finland, June 2016.

[9] D. NamdeoHire, "Secured wireless data communication," International Journal of Computer Applications, vol. 54, no. 1, pp. 27–30, 2012. [8] A. A. P. Ratna and R. F. Sari, "A test bed implementation of secure and lightweight privacy preservation mechanism using scrambled Fibonacci and XOR for ZigBee," in Proceedings of the Region 10 Conference, TENCON 2017, pp. 863–868, George, Malaysia, November 2017.

[10] Y.-S. Tsai, C.-Y. Chu, M.-C. Li, Y.-H. Lin, and P. Chen, "Intelligent DC power monitoring system and sensor network based on ZigBee-equipped smart sockets," in Proceedings of the 5th International Symposium on Next-Generation Electronics, ISNE 2016, Hsinchu, Taiwan, May 2016.

[11] Mohini Chaube, Gaurang Singh, Mrunmayee Kore, Shruti Nema, "Distributed Power Systems Automation using SCADA System", 2019, International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering Vol. 7, Issue 2, February 2019

[12] Nelson S. Andres, Christopher V. Maglaque, Ira C. Valenzuela, "Reliability and Safety Assessment of SCADA Project Implementation of Peninsula Electric Cooperative", Journal of Computational Innovations and Engineering Applications 5(2) 2021: 22–27