ENHANCEMENT OF SELECTIVE COORDINATION FOR SAMAR STATE UNIVERSITY ELECTRICAL POWER SYSTEM

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Major in Electrical Technology

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APPROVAL SHEET

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Thank you very much.

Jonas

DEDICATION

I am dedicating this humble piece of achievement to:

SWEET L. VISTA, my wife;

My children;

IMANUEL JONAS L. VISTA

CHARLES JONAS L. VISTA

FRANC FLORENZ L. VISTA

And to

Almighty God

ABSTRACT

The main purpose of this study was to assess the selective coordination of (3)- three phase electrical power system of Samar State University main campus. The study employed quantitative descriptive research design. Quantitative since the study aimed to identify and calculate extent of actual operational capabilities of existing Samar State University electrical power system in terms of selective coordination of protective devices, service entrance, feeder conductors, its respective rating and capacity if subjected overloading. Power consumption of the university increased in the last eight (8) years starting from year 2010 up to 2017. The maximum connected load utilized is equivalent to 2,767, 689 kW-Hr; average is 345, 960 kW-Hr and the lowest is 287, 600 kW-Hr. Overloading is the core problem in Samar State university electrical power system for the past eight (8) years. Administration replaced the damage transformer, the potential cost of damage was Php 278,250.00. The power loading of the electrical system reached up to 1,070. 565 kW in total. The increase of energy consumption of the university should be considered as one of the indicators for electrical system enhancement. Electrical overloading is a recurring problem in the electrical system as a result of load expansion. Electrical system is in a state of active failure. For the recommendation, enhancement of Samar State University electrical power system is needed starting from the first private pole, transformer up to branch feeder circuit supplying per building.

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Chapter 1

THE PROBLEM AND ITS SETTING

Introduction

In the year 1988, Samar State Polytechnic College (SSPC) was composed of school buildings designed for a classroom instruction. These building were designed from single, two and three storey which comprises of electrical technology building, garments technology, old administration building, old related building, old college of arts and sciences building, guest house office, metal and fabrication building, and college of engineering. Experienced electrical distribution of power are unbalanced carried by overloading and affected the rating and sizes of feeder conductors in the electrical power system including the protective over current devices in relative to loads per individual feeder supplied to institutional building of the college as performed from electrical maintenance (Bañez,1988). The electrical power system was a mixed installation of overhead open conductors extended from main service equipment, rated at 250 amperes and provided power protection to individual feeders. Most of open feeder branches are attached in ceiling consumed fabricated pin and racks and passed inside the classroom ceiling heads into individual fuse type main switches.

Location of electrical service situated in main entrance of the college supported in distribution pole from electric utility power company. The electrical system was three phase three wire total of 75 kVA or equivalent to 3-25kVA in banking transformer, sized service entrance conductor of #2 AWG or 3 set of 1-60.0 mm^2 THW copper conductors. This 60 amperes feeder energizes lighting loads for classroom and power outlet for general use utilization of electric fans and other small appliance loads. Difficulties in unbalance of power, fluctuation are encountered and overloading into the system is experienced due to the system depleting capacity and continual increasing of mixed loadings. The electrical feeder was affected, under voltage are major problem since electrical loads in the system is continuously increasing. Actual rating value of power required to the college due to change in building use was from common classroom to mixed air-conditioned rooms upgraded capacity rating of transformer was replaced to 100kVA per phase, service entrance conductor was enlarged to 3 set of 1-80.0 mm^2 THW per phase transported entire loads served all demands of the college.

Technical and electrical system improved, relocated the feeder systems and was anticipated due to development plans and energy consumptions of the college. Power house was created and houses main disconnect switch and control protections. Clustered and paired feeder loads to load balancing generated segregation of three phase and single phase system loads. System overloading and conductor heating still experienced in the electrical system. Explosion of protective devices of electrical power system was common in the repair and corrective maintenance activities (Abayare, 1998). Main distribution panel consisting of five branches were installed in electrical system. Individual disconnect was established de-energized feeder to respective buildings. Manual transfer switch are transferred, 2-600 ampere fuse at 3 set of 1-250.0 mm^2 THW service entrance connecting 312 kVA three phase diesel generator as appeared in figure 3. Increased and addition from existing system of load resulted from infrastructure projects, and change of mixed loadings the capacity rated of 100 kVA was challenged in change of used from linear load consumption , inductive to motorized loads the air-conditioning load in administrative functions of the college. Power conservation maintenance scheme and energy awareness in the use of electricity was initiated to reduced energy consumption.

In the conversion of Samar State Polytechnic College to Samar State University in the year 2004, selective coordination of electrical power systems faced outmoded capabilities. Power distribution per building depleted the system capacity resulted in increased projects of the university. Infrastructure and development services office implemented air-conditioned room projects ready for innovative instruction, research and extension. Additional loads to the electrical power system was retrofitted, relocated, adjusted and reserved power was university main concerned. Allocated additional loads contributed problem in electrical maintenance and safety of system due in increased of load current added in electrical power system. System capacity of the university is 300 kVA, 3-100 kVA (Mabini, 2009) and service entrance conductor wire is 3 sets of 3-80.0

mm^2 THW stranded pure copper wire protected by 1,250 ampere main circuit breaker.

System overloading problem was observed in explosion of 100 kVA transformer and damaged winding of transformer unit resulted in power interruption in the university last second week of February 2016. Electrical power system of the university in its maximum utilization needed of load calculation study as proof evidence to enhanced system as solution to power system problems. It is therefore timely that this study will be conducted.

Today, Samar State University main campus had increased infrastructure projects to meet challenged of new millennium and served demand of quality education. Construction of new institutional building had significant changes to the existing electrical power system. Additional infrastructure demanded additional power requirement and intended used. Meaning, it should add stability performance to installed rating capacity of the university. Importance of selective coordination study (National Electrical Code of America; NEC article 701, 2011:18) in any power system is vital in the selection of rating protection for feeders, branch circuits, motors up to transformer and generator. In the past eight years since year 2010 to the year 2017, energy utilization in kilowatt-hours doubled (figure 5) and the electrical power system is in critical conditions. The load of the institution doubled and had significant impact increased, but the existed electrical power system still remain the same rated capacity for eight years.

Similarly, in Norwest Samar State University in Calbayog City, they also have experienced problems in electrical power system. Installed transformer unit had oil leakage coming out in the surface cover which resulted to temporary power black-out in the campus. Finally, this study is intended to know the extent of actual operational capabilities of existing Samar State University electrical power system in focused to selective coordination of protective devices, service entrance, feeder conductors, its respective rating and capacity if subjected overloading. Calculated the actual peak current, transformer ratings, sizes of over current protective devices, feeder conductors and recommended the acceptable power distribution plan suitable for the Samar State University electrical system that are complying to standards of existing laws of electrical system as mandated in the Philippine electrical code 2009.

Statement of the Problem

The main purpose of this study was to assess the selective coordination of (3)-three phase electrical power system of Samar State University main campus. Specifically, the study answered the following questions:

1. What is the historical profile of the electrical power system along?

    1.1 power consumption for the last 8 years; and

    1.2 existing power distribution per feeder

    1.3 power system layout

2. What are the problems encountered in the power system for the last 8 years?
3. What is the status of the power distribution in the following:
    3.1 Amount of power per buildings;
        3.1.1 lighting;
        3.1.2 equipment; and
        3.1.3 laboratory facilities?
    3.2 Power system infrastructures?
4. What power distribution system must be designed in compliant to Philippine electrical code?
    4.1 peak current consumption of the present system;
    4.2 power system infrastructure;
    4.3 power service; and
    4.4 total power cost

Theoretical Framework

This study is anchored in the concept of grey theory in evaluation of design for energy efficiency of buildings based on hierarchical analysis. As summarized by Glennon (2013:1-4) on selective coordination of power systems, preventive maintenance and testing will not ensure that electric power system would operate reliably and safely when an abnormal condition occurred. But periodic engineering studies that calculate system short-circuit currents, evaluated protective equipment´s suitability to handle those current's, and coordinate how those devices interact with each other and combination of comprehensive maintenance program and engineering analysis are the answer. The present study is also supported with thevinen's theory for three terminal networks in poly-phase circuits, Busmann (2010:3-29) of three phase unbalanced electrical networks applicable to power systems with the use of complex quantities. The utilization of power formula in the combination of impedances in determining the significance of apparent power, current and reactance based in the existing Samar State University electrical power system. Formulate electrical system analysis to respective parametric values in the system as to load connected and derived equivalent impedance network.

The use of electrical design analysis such as short circuit calculation and voltage drop calculation in per unit value under the principle of symmetrical components (Philippine Electrical Code; PEC 1 article 1.2, 2009:17-19,) are used in sizing required current rating of circuit breakers, feeder protection and main service equipment protection the capability to carry short circuit fault if followed proper desired selective coordination. The study used short circuit calculation analysis to established interest in available fault current value to service entrance and feeder using tables and standards published by product manufactures for circuit breakers, wires and cables for conductors. The voltage drop calculation and percent voltage drop are used in analysis in the part of service entrance conductors and feeder distances and impedances in conductors are treated.

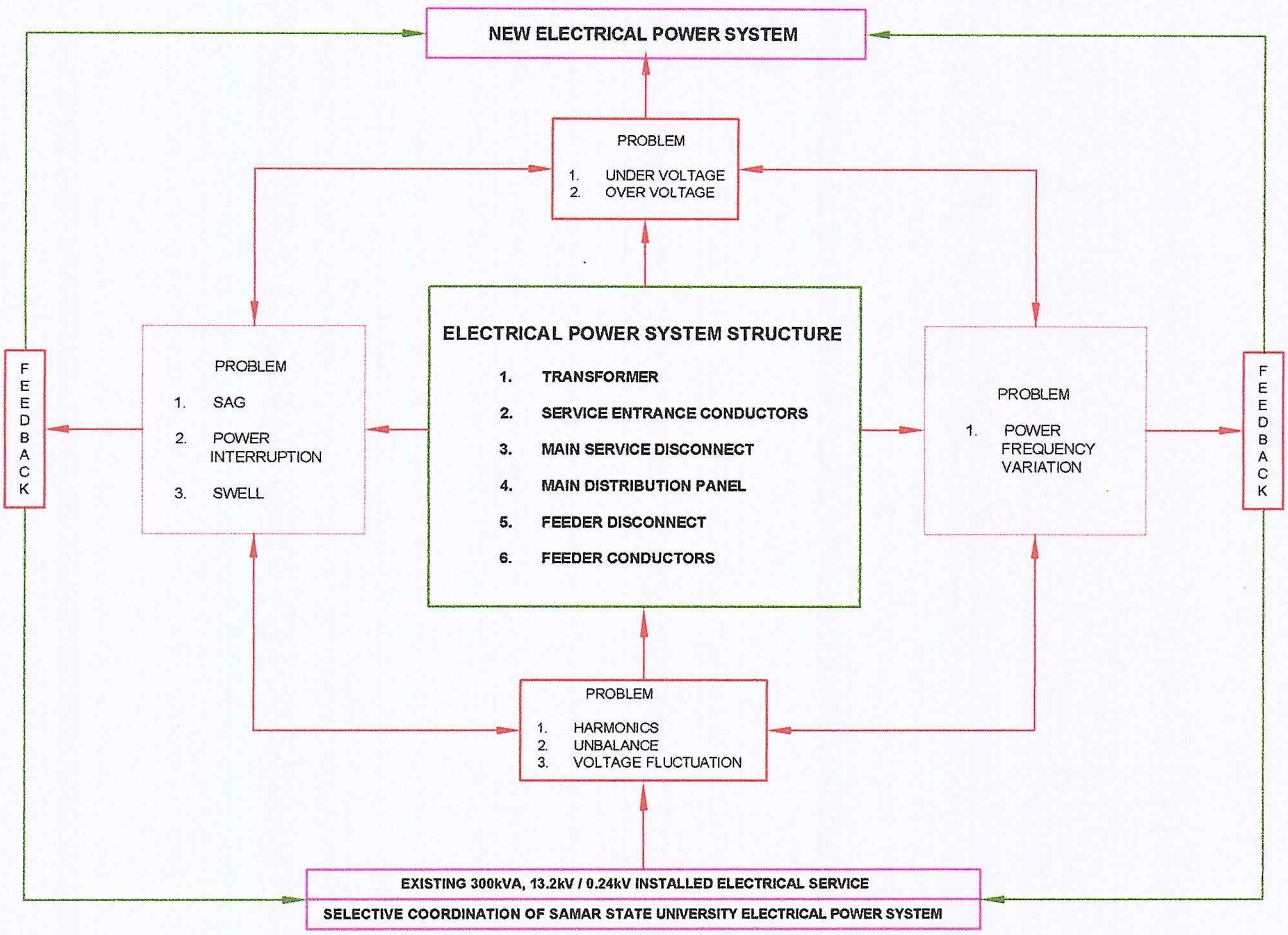


Figure 1 Conceptual Framework of the Study

Conceptual Framework

Figure 1 shows the conceptual framework of the study illustrating, among other things, the research environment, and the major variables involved in the study. The box at the base of the paradigm reflects the research environment of the study which is the Samar State University Electrical power system and is represented by descriptions of the load capacity, rated voltage and installed apparent power. The centre main box represented electrical power system structure of Samar State University, namely: Transformer, Service Entrance Conductors, Main Service Disconnect, Main Distribution Panel, Feeder Disconnect, and Feeder Conductors serving the different building of the institution. The four corners of boxes indicated the problems as variables derived from the respondents that affect the electrical system coordination based on their supervision and actual problem exposure. The problem variables are overloading, under voltage, overvoltage, swell, harmonics, sag, power frequency variation and voltage fluctuation.

The problems are analysed as to contributions in extent of enhancement of the electrical power systems especially in coordination approach as to what level of design and power quality factors will be achieved in existing electrical system of Samar State University. Determine the applicable load peak current, and power to established stable system performance in consideration of energy consumptions and responsive electrical installations as stated in recommendations and conclusion of study.

Significance of the Study

Enhancement of selective coordination for Samar State University electrical power system is relevant and necessary. As of this writing, no assessment related to power system coordination was undertaken yet. Moreover, the data obtained from its assessment would, in one way or another provide benefits and insights to more wider electrical management plan for electrical power system improvement in Samar State University main campus, and to be used as data for electrical system improvement in constructing a proper coordinated electrical system as to required rating of transformer, service equipment, service entrance conductors, feeders and design of power distribution.

Administrator. The result of the study will serve as bases for information for the Infrastructure and Development Services for the future infrastructure projects. Technical recommendations will help the Administration in preparation of building designs in the future. Also, in the concern of maintenance services, the data will served as primary information in the operation of their task especially in electrical works for electricians and other related personnel as to the circuit descriptions of feeders and circuit breakers in respective distribution panel board. The result of the study will be an input in creating an efficient electrical system that promotes safety and productivity and the economic aspects by selecting proper devices that matches the needs of the university related to the use of electricity as counterpart in the development of the university.

Power providers. The data can be used by electric utility or power providers for forecasting baseline capacity of apparent power installed as to appropriate and recommended design of electrical power system suitable to the needs of the university.

Electrical engineers. The result of the study will help the electrical engineers in interpreting realistic voltage drop application analysis in designing institutional buildings. Data are references in the understanding of the application of proper coordinated electrical system in the electrical major subjects especially in the electrical system designs. How cascading cases affects the electrical system efficiency if not comply effective selective coordination performance of circuit breakers in relation to power stability.

End-user of buildings. The data can be used as references in future purchases in maintenance of their buildings and also the details of physical structures of the building related to electrical systems.

To the future researchers. The outcome of this study will also serve as a reference material for future researchers who will be motivated to study this subject matter or related to it.

Scope and Delimitations

The scope of the study will focus on the assessment of selective coordination of Three (3) Phase Electrical Power System of Samar State University main campus (figure 2). The study includes transformer, main service disconnect, service entrance conductors, main distribution panel, feeder disconnect, and its respective feeder conductors extending or serving power per building. The main distribution panel as a whole or the entire distribution panel of electrical power system structure is included serving and extending from the main final over current device of point of service to the point of use as considered as feeder. The individual panel board or distribution panel attached in the building supplying or connecting the branch circuit serving the different branches to power individual loads is not included in this study. This refers to the fabricated panel temporarily connected or attached to the building that serves as a purpose of disconnecting power in terms of maintenance purposes or any, are not included in this study.

The two wire (2) single phase system and its associated loads are not included in this study. This specifically pertaining to the single phase distribution panel commonly found inside the building. The electrical grounding system of the Samar state university power system is included in this study. This refers to the grounding systems bonded within the electrical system beginning in utility source and building wiring premises. Conductors and its associated grounding wires is considered as grounding provided that it will not pass through in the single phase panel serving lighting circuits and convenience outlets.

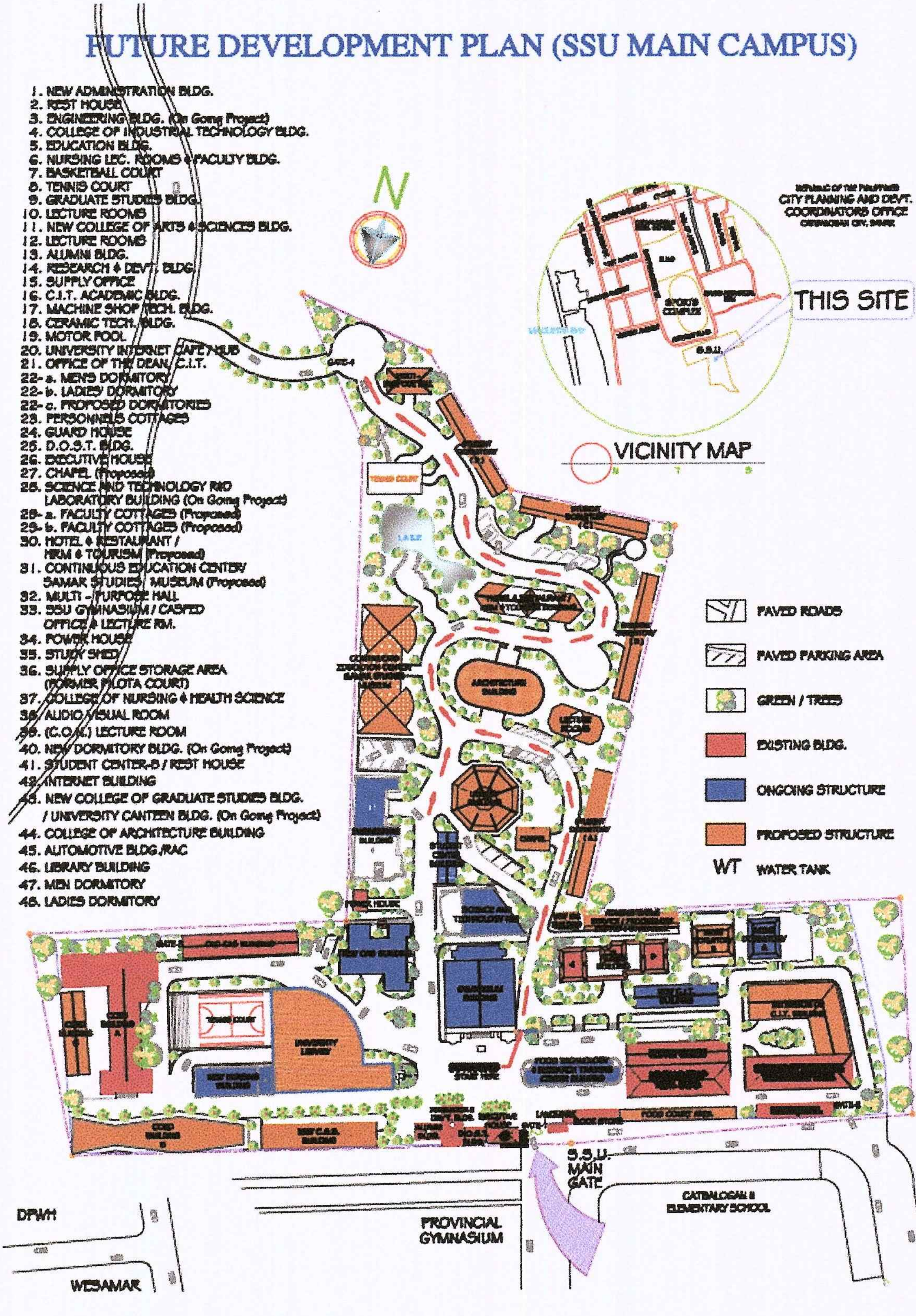


Figure 2 The Research Environment

Definition of Terms

The following terms were defined conceptually and / or operationally for easy reference and understanding of the study.

Amperes - The current that a conductor can carry continuously under the conditions of use without exceeding its temperature rating (Article 1.1.1, PEC 2009: 5). In this study it refers to load current capacity utilized by branch circuit and feeders per building.

Branch circuit –The circuit conductors between the final overcurrent device protecting the circuit and the outlet (Article 1.1.1 PEC 2009: 5). In this study it refers to lighting, power outlets and appliances loads.

Circuit breaker - A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating (Article 100 NFPA 70, NEC 2011: 28). In this study refers to the highest protective device rating of branch circuit and feeder per building.

Demand Factor - The ratio of the maximum demand of a system, or part of a system, to the total connected load of a system or the part of the system under consideration (Article 100 NFPA 70, NEC 2011: 28). In this study is defined as percentage of total unit load value in every schedule of loads per building expressed in kilovolt amperes.

Disconnecting means - A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

(Article 100 NFPA 70, NEC 2011: 28). In this study is defined as a point in electrical system accessible of isolating short circuit current such as main switch.

Feeder/Feeder conductor - All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device (Article 100 NFPA 70, NEC 2011: 28). In this study it represents the conductor to respective institutional building of the university, such as the college of industrial technology.

Grounding conductors - A system or circuit conductor that is intentionally grounded (Article 100 NFPA 70, NEC 2011: 29). In this study is defined as the non-carrying current conductors specifically designed for protection of panel board serving the building due to un-wanted sources of current touching the live conductor.

Harmonic - a type of non-linearity distortion characterized by the production of output components with frequencies which are integral multiples of the frequency of the sinusoidal input signal (Electro Technical Commission, IEC 60050, 801-30-03). In this study is defined as current generated from non-linear loads such as electronic lighting.

Impedance - refers to a given measurement location, the quotient of phase voltage and phase current during power transmission assuming no power system fault exists (Electro Technical Commission, IEC 60050, 448-14-11). In this study is defined as combination of resistance and reactance.

Interrupting rating- Is the highest current at rated voltage that a device is intended to interrupt under standard test condition (Article 100 NFPA 70, NEC 2011: 29). In this study refers to rated current rating size of circuit breaker expressed in kilo amperes.

Overvoltage – voltage between phase conductors having a peak value exceeding the amplitude of the highest voltage of the system (Electro Technical Commission, IEC 60050, 448-14-32). In this study it is define as the load changes, faults, over compensationin excess of the system voltage delivered by the utility over riding the 230 volts limit. Most commonly damages the computers, printers if it happens in minute of occurrence. Explosion may occur if the load has traditional protection capabilities such a simple automatic voltage regulator made of core laminated sheet and copper winding.

Panel board - A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cut-out box placed in or against a wall, partition, or other support; and accessible only from the front (Article 100 NFPA 70, NEC 2011: 31). In this study it refers to panel casing or enclosure that houses a group of circuit breakers protecting the branch circuit loads.

Power Frequency Variation - The inconsistency of power supplied by stand-by generators or poor power infrastructure (Ignatova, 2015:3). In this study it refers to injected electrical power to electrical system at a glance without accurate frequency stabilization.

Power Interruption - Un-coordinated electrical system and or excessive current engagement in the transient period of fault (Ignatova, 2015:9). In this study it is define as absence of utility power due to faults or equipment failure.

Protective Device– A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of over-currents between its rated current and its interrupting rating (Article 100 NFPA 70, NEC 2011: 31). In this study it is define as devices that protect the circuit from over-current such as fuse and circuit breakers of building.

Sag - Utility or facility faults due to the result of combination of loads in a branch circuit or feeder (Ignatova, 2015:3). In this study it is define as common connection in single circuit connecting. Example air-conditioning unit along power convenience outlets and lighting circuits commonly manipulated in additional or corrective maintenance modification.

Selective Coordination – Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings (Article 1.1.1, PEC 2009: 7). In this study it refers to the proper selection of rating of circuit breaker, conductors and transformer in performing electrical pick-up setting in the event of fault in the electrical system. Also, covers the proper sizing of transformer, service entrance conductors and feeders in relation to loading.

__Service__-The conductors and equipment for delivering electric energy from the service utility to the wiring system of the premises served (Article 100 NFPA 70, NEC 2011: 31). In this study it refers to electrical power system installed capacity and protections including electric metering facilities given by the cooperative or utility having jurisdictions.

__Service Entrance conductors__ -The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop (Article 100 NFPA 70, NEC 2011: 32). In this study it refers to group of conductors delivering total current from secondary of existing electrical power system.

__Service Disconnect/Equipment__- The necessary equipment, usually consisting of a circuit breaker(s) or switch(is) and fuse(s) and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cut-off of the supply (Article 100 NFPA 70, NEC 2011: 32). In this study it refers to the largest circuit breaker rating protecting the building.

__Swell__ - Load changes or any continues change-over of loads in a particular circuit and specific design (Ignatova, 2015:9). In this study it is define as any continues change-over of loads in a particular circuit. A common example is supplying 28 ampere in a 15 ampere circuit breaker system.

__Transformer__ - electric energy converter without moving parts that changes voltages and currents associated with electric energy without change of frequency (Electro Technical Commission, IEC 60050, 151-13-42). In this study it refers to installed capacity rating in kilovolt-ampere given by electric utility.

Unbalance – Condition in a polyphase system in which the rms values of the phase element voltages (fundamental component), or the phase angles between consecutive phase element voltages, are not all equal (Electro Technical Commission, IEC 60050, 614-01-32). In this study it is define as the un-equal distribution of single phase loads in the electrical systems. This is commonly found in the building which has un-avoided revision in the implementation of loadings in maintenance installation practices without any analysis or calculation pertaining to a specific load.

Under voltage – Protection intended to operate when the power system voltage is reduced to less than a predetermined value (Electro Technical Commission, IEC 60050, 448-14-33). In this study it is define as load changes, overload, and faults below the limit voltage specification. A most common example is a load being utilized at 198 volts instead of 230 volts at nominal. A very dangerous scenario in the electrical system especially with under rated systems common in the provinces utilizing multi-ground system at peak utilization.

Voltage Fluctuation –Series of voltage changes or continuous variation of the rms or peak value of the voltage (Electro Technical Commission, IEC 60050, 614-01-06). In this study it is define as a load exhibiting significant current variations. It is commonly shown as light flicker and equipment malfunction.

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents the related literature on selected coordination of electrical power system studies in which the researcher patiently reviewed from books, manuals, handouts, brochures, documents and other readings which have bearing on the study. It also presents findings of related researches and studies from results in other technical studies particularly in design methods.

Related Literature

Selective coordination analysis studies started and been required for emergency systems in health care facilities since 1985. The iteration of National Fire Protection Authority of America (NFPA 70), National Electrical Code of America (NEC 2011), article 700:28 states "Emergency system over current devices shall be selectively coordinated with all supply-side over current protective devices." This same sentiment is also reiterated in NEC 2011, article 701:27 for Legally Required Standby Systems and in NEC 2011, article 708:54 for Critical Operations Power systems. NEC 2011, article 517:30 further enhances the requirement for selective coordination of a health care facility by requiring the essential electrical system to be coordinated for the "period of time that a fault's duration extends beyond 0.1 seconds." This requirement aligns with the current iteration of NFPA 99, Health Care Facilities Code, and finally quantifies a time duration for which the system is to be coordinated.

In the NEC 1993, article 620 stipulated the elevators, escalators and moving walks should have a coordination study. The emergency systems both in commercial and health care facilities where included as mandated in NEC 2005, article 700:27 shall have proper coordination system to support life in the event of power outages due to arcing of short circuits generated by faults. In National Electrical Code (NEC) 2005, Article 100:28 revised the new definition of selectivity as the "Coordination (Selective) stipulates "Localization of an over current condition to restrict outages to the circuit or equipment affected, accomplished by the choice of over current protective devices and their ratings or settings." In these version, of transition requirements the engineers is mandatory required to design systems which are safe and functional before presenting the electrical systems to clients or to the concerned local authorities and to scrutinize plans in the existing electrical systems for effective use.

In National Electrical Code of America (NEC) 2011 requirements, the scope of selective power coordination as to system proper design shall include normal source to the line side of the automatic transfer switch, load side of any emergency system, and the emergency source to the line side of automatic transfer switch. Today requirements, in the selectivity coordination and design shall follow minimum requirements for effective coordination of protective system zones to limit coordination problems in the systems. These are the transformer, panel board and over current protective devices. Under these requirements, the system on low voltage shall have isolation point on the system to protect transformer, avoid the same location of lighting panel as the same place for distribution panel and size secondary breakers to 125% to allow coordination between secondary main and feeders.

In the integration of the professional accredited organization of the Institute of Integrated Electrical Engineers of the Philippines Incorporated (IIEE) , the strict compliance of applicable wiring methods to promote safety on buildings and other structures inhabited by person regardless to the different occupancy use were inspected by the building officials or the concerned authority having jurisdictions. Derived from the implementation of the Philippine Electrical Code (PEC) of 1973 up to 1975 on the selectivity of electrical power systems was not a mandatory requirement in creating electrical designs for commercial, institutional and industrial system. In the year 1979, the selective coordination analysis is found in the preparation of electrical power designs as minimum criteria in or passing and securing electrical permits. It was incorporated the decisions of technical electrical engineers of the PEC 1 committee to revised the mandatory requirements in the electrical power system design analysis after the tragedy of ozone disco killing innocents young male and female inside the commercial establishments in the year 2000.

The analysis was found out that the commercial establishment has a poor electrical system. Again it was followed in year 2001 where the six (6) storey rentable apartment building where found that electrical system has no selective coordination study, killing occupants in the blaze of fire due to faulty wirings as per fire investigators in the local authority having jurisdictions.

In Philippine electrical construction industry setting, the Philippine electrical code as published on September 14, 2009 as the core document needed to be followed by Filipino electrical engineers and skilled personnel mandated the mandatory requirement of design of selective coordination of protective devices both on high and low voltage systems as indicated in the plans and specification of article 1.3.2.1 for electrical plan requirements. These will include type and rating of main disconnecting means, over current protection and branch circuit wiring. In the type of wiring, includes service entrance feeders, sub-feeders and branch circuit wires for lighting and/or power load. In the month of January 19, 2015, a memorandum was sent by the Institute of Integrated Electrical Engineers of the Philippines Incorporated (IIEE) and address to Department of Interior and Local Government (DILG) that the applicable A Short Circuit and Coordination Study is mandatory needed in the selection of over current protective devices for selection of electrical components of electrical systems specially in critical for the safe, efficient, and economical operation of any electrical distribution system. Emphasizing the calculation of the electrical analysis in which the short circuit study will help to ensure that personnel and equipment are protected by establishing proper interrupting ratings in the electrical system designs.

The importance of a Coordination Study (Article 110 , National Electrical Code of America, NEC 2011:119-110) in maximizing power system selectivity by isolating faults to the nearest protective device, as well when an electrical fault exceeds the interrupting rating of the protective device, the consequences can be devastating, including injury, damaged electrical equipment, and costly downtime. Another reason is to avoid nuisance operations that are due to transformer in-rush or motor starting operations. The mandate of the Philippine electrical code of 2009 in section f of the design analysis produce results that are needed to be included in determining the over current capacity of protective devices for any electrical power systems and other related purposes.

Related Studies

The following are relevant studies reviewed by the researcher that help him in planning and structuring important data and information.

Mabini (2012) conducted a study entitled "assessment of potential use of electrical based facilities waste for Samar State University power system" concluded that conservation implementation of the government on the energy efficiency must have comprehensive maintenance plan that includes corrective and preventative maintenance planning scheduling. In this study he stipulates facilities wastes as primarily contributor to high cost of energy consumption of the university. His recommendation is to improve the connected load set-up of the power house due to long distance of wire that causes voltage drop.

The study of Mabini has a similarity in the area of the connected load set up of the power house of the SSU low voltage power system as indicated in the specific objective number 1 in relation to the current status of the existing electrical power systems. However, he does not mention the total load current of the university and what are the bases for system improvement especially in the installed alternating capacity service of the university. Unlike the present study will determine the true rated load current and the expected load in kilovolt ampere (kVA) due to increase of institutional building projects of the university.

Abayare (2014), in his study on the "SSU power system assessment basis for system design and maintenance program" concluded that power quality is a crucial area to be considered in operating distribution system especially if efficiency and reliability is concerned. The Samar State University power system suffers already poor quality supply because of voltage drop, harmonic distortion and voltage unbalance. It must also include restructure the power distribution system to achieved good power quality.

The study of Abayare has a similarity of this study in the field of voltage drop aspect in the part of assessment of the SSU low voltage power system. However, this present study focus on the selective coordination among over current protective devices in three phase systems as to the capability of the system rating to carry load at the event of faults in the existing electrical systems and to determine the scope of enhancement in proportion to load requirement while the other one is the factors on power quality contributors due to poor maintenance program and other budgetary accumulation negligence for system improvement and continuous non-coordinated electrical construction planning in the infrastructure development.

In the study of Larsen (2008) of a new approach to low voltage circuit breaker short circuit selective coordination is to compute the isolating point of protection in the distribution systems in the health care stand-by systems. The study has a similarity to present study only that the application is more on health care facilities and to provide automatic quick response to the system of emergency diesel facilities in the event of fault on the electrical systems. His study has similarity as indicated in the specific objectives number 2 and in number 5 in particular to the current interrupting rating of selected over current devices and the technical engineering management plan.

Larsen recommends protective zones to essential circuits to promote life and safety of the occupants creating a more responsible system design that will eliminate cascading effects due to the results of not proper coordinated electrical systems. He mention the time current curve performance of low voltage three phase electrical system failures caused by overlapping of current rating of circuit protections.

A study entitled: "Analysis of a genetic algorithm (GA) Based Distributive Power flow Controller (DPFC) for Power System Stability was conducted by Bajpayi and Thakur (2016) with the aim stability of Power system is the capability of an electric power system, for a given initial operating condition, system regain a stable condition after being applied to a physical disturbance. Power system voltage stability includes generation transmission, and distribution. Voltage control, reactive power compensation and, rotor angle (synchronous) stability, protective relay and control center operations, all influence voltage stability. Power system stability affected by: Large distance between generation and load, Unfavorable load characteristics, Bed coordination between various control and protective system, Different of Reactive Power in transmission line under Heavy Loads, More Reactive Power Consume at Heavy Loads condition, and Occurrence of Contingencies. The above study is related to the present study since it deals with power system stability among loads of electrical power. Their only differences are the present study focused in distribution of power at low voltage in distribution system, unlike the other one is applied to transmission systems utilizing extra high voltages.

The study of Roland (2016) on "Establishing an Electrically Safe Work Condition" specifically related to Racking Electrical Breakers for low voltage electrical equipment, that a maintenance risk assessment must be performed prior to or before performing such any task. The risk assessment determines the risk control measures to be put in place prior to performing the work. He concluded that perform and document a risk assessment in any maintenance works for electrical systems especially in a live tapping or connections.

The study of Roland (2016) on "Establishing an Electrically Safe Work Condition" has a similarity of the present study because it discusses electrical safety work place as indicated in the specific objectives on the study of efficient technical engineering management plan it only differ since the risk assessment program is not part of the study.

The study of Waters (2015) states that NFPA 70E has become a recognized standard for electrical safety. It is steadily replacing the inconsistent, non-standardized method of transferring electrical safe work practices by journeymen. Apprentices today are introduced to NFPA 70E during their apprenticeship education and are instructed in the use of electrical safe work practices while in pursuit of becoming licensed electricians. Instruction on electrical safe work practices during the apprenticeship stage is currently changing the electrical safety culture of future electricians. The present method of transferring electrical safe work practices still faces opposition from both legacy journeymen electricians and employers who have yet to accept, or who have opted not to embrace, the use of NFPA 70E.

Legacy electricians can be set in their ways and resistant to change while continuing to use the old methods of transferring electrical safe work practices. Employers can also undermine the learned electrical safe work practices of apprentices. They do this by using their leverage as employers to persuade or coerce employees to ignore these safe work practices as unnecessary or costly.

Electrical workers, regardless of experience, are faced with a major barrier when first introduced to NFPA 70E,"The Standard for Electrical Safety in the Workplace," and an erroneous electrical safety culture pre-exists.

The study of Waters has a similarity to the present study because it discusses the specific objectives especially in 4.2 of the study personnel requirement that is responsive to the needs of electrical engineering expertise for system capacity of more than 230 volts 500kVA. However, the present study is in the process of creating recommendations suitable for comprehensive maintenance plan.

The study of Ignatova and Hoeppner (2015), derived on the power quality framework to be followed in the implementing continuous, iterative quality power management is an area of growing concern for end users due to the frequency and financial impact of power quality issues: 30 – 40 percent of all unscheduled downtime today is related to power quality problems. In the Industry sector, for example, the cost of poor power quality can reach four percent of annual turnover and is often equivalent to the total balance payable on a facility's energy bill. Worldwide user surveys show that complaints about power quality-related disturbances– harmonics, voltage dips, flicker, and so on– are increasing every year. This is due to the number and variety of power quality disturbances, growing equipment sensitivity, and increasing user awareness. Today, an end-user electrical installation is exposed to a high number of various power quality problems; 80 percent of these disturbances are generated by user-owned equipment. In industrial facilities, for example, such disturbances can be caused by nonlinear loads like arc welders or variable speed drives, capacitor switching, or large motor starts. In commercial buildings, electronic equipment like computers, printers, and servers may also generate additional power quality disturbances. The other 20 percent of power quality disturbances come from the energy provider, as even the most advanced transmission and distribution systems are not able to guarantee 100 percent energy availability. Modern transmission and distribution systems range between 99.9 to 99.99 percent availability, depending on redundancy level, geographical location, and voltage level of the network. Even with 99.99 percent energy availability, the equivalent interruption time amounts to 52 minutes every year.

The study is similar in this present study in the power quality issues namely unbalance voltage and under voltages. The difference only on the concern of electrical protection in the 230 volts electrical systems pertaining to institutional establishment or structure is not under their objectives or the main interest of their study, and they focus more on industrial facility or medium voltages that are common to manufacturing industries.

Chapter 3

METHODOLOGY

This chapter presents and describes the research methodology applied to this study. It includes the research design, instrumentation, sampling procedure, data gathering procedure, and data analysis employed in processing the gathered essential data. The results of the methods were used in presenting a review in the interpretation of selective coordination of (3) three phase electrical power system of Samar State University main campus.

Research Design

The study employed quantitative descriptive research design. Quantitative since the study aimed to identify and calculate extent of actual operational capabilities of existing Samar State University electrical power system in terms of selective coordination of protective devices, service entrance, feeder conductors, its respective rating and capacity if subjected overloading. Calculated peak current, transformer rating, rated sizes of protective devices and feeder conductors.

Descriptive since the study used electrical system design analysis pertaining to unbalance power system, three phase faults that uses per unit method calculation, voltage drop calculation based on electrical quantities such as impedance, voltage, current and power in complex form and their numerical relationship to energy consumptions. Inferential statistical tool such as mean were used in the analysis of data.

Instrumentation

The researcher employ interview, standard value derived from codes and actual observations with electrical measuring instrument to elucidate the desired data and information.

Interview. An unstructured interview to respondent conducted by researcher affecting to history of electrical power system and their selective coordination components.

Actual observation. In actual collection of data and retrieval of important technical information, the researcher uses electrical measuring instruments to facilitate analysis especially in the peak current value of currents and the calculated design current to the individual buildings.

Code (Philippine Electrical Code, 2009). The use of code as guide particularly Philippine Electrical Code part 1 of 2009 was used to identify reason to form a standard in computation that resulted to bases in comparative analysis between the over size and under size or essential in power systems applicable to building loads. The researcher used the code to evaluate the electrical system components as to the rated specification, capacity and approved electrical system that complied and responsive.

Checklist. In the checklist reflected rating of electrical equipment and materials including transformers, protective devices, wires and conductors and other related information for existing electrical power system.

Validation of the instrument. In the actual observation utilized electrical measuring instrument concluded that peak current consumption records 949.4 amperes and 378.219kVA using Mean formula. The said value indicated that total connected load exceeded the existing SSU electrical power system rating at 26.073 percent.

Data Gathering Procedure

The researcher wrote a letter to the two university president; Samar State University, Catbalogan City, Samar; and North Western Samar State University on January 10, 2018 and February 08, 2018 asking permission to conduct interview to the target respondents. After obtaining an approval, the researcher proceeded unstructured interview in order to derive records pertaining to the electrical power system structure of the university such as circuit breaker, transformer and energy consumptions per month. Measure the actual average distance of the feeder lines going to respective buildings with the use of measuring tape and compute the average mean respectively. The collection of data in relative to impedances will base on the cable manufacturer standard as well as the reactance and resistances. The detail of data taken in the processing of the full load current is by using the digital clamp-on tester with the permission of the maintenance personnel. Full load current in amperes is derived from the average mean as to five days in operation to get the significant value. Electrical plan for on-going projects is used as bases in determining the full load value in amperes per building feeder. The other interview was conducted as benchmarking of related problem regarding power system enhancement.

Statistical Treatment of Data

The data gathered was recorded, tallied, tabulated analyse and interpreted. The average mean formula was utilized in average mean distance from service point of connection to service point of use especially intended for service entrance and to respective feeders of building. In determining the fault current available, electrical design analysis is used to analyse data. These are the short circuit calculations came from per unit computation derive from impedance, voltage and current available in existing electrical systems. Afterwards, voltage drop calculation and percent voltage drop at point of connection to respective panel board is also considered in study in order to determine approved rated sizes of wire or conductors.

Mean. The mean is used to calculate average distance of conductor length from point of service to e point of connection use of building last attached assembly. The distance was summarized in tabulated format that included CIT/CON, COED/NCAS, Admin, Old CAS/Guest house and the CGS building. Average distance to respective building was used in calculation of system voltage drop, percent voltage drop at the top of supply line per panel. Another data was analysed uses the mean is current. Average full load current per respective feeder to its building, the current was recorded in 10 hours based starting from 8 am in the morning and ends up 7 pm in the evening where there was high possibility of loading consumptions.

Electrical power system design analysis. In preparation of electrical design analysis, there are three system components to consider. These are the following:

a. **Impedance diagram**- Reflected details of impedance network of existing electrical system from transformer to respective panel with respective length of conductor and full load current.

b. **Short circuit calculation**- Represented assumed proposed points of faults and highest fault current level in existing electrical system in response to abnormal current using per unit value computation in interpretation of data including voltage percent drop per panel board. Fault calculation indicated capability of over current device to such amount of current, and possible area where weak points in the system that needed immediate replacement or increased.

c. **Voltage drop calculation** – Resistance and reactance, summary of cable specification retrieved in actual observation based in product cable wire manufacturer providers and information of voltage increase percentage and needed increased size of conductor relative to change of voltages in point of connection to respective panel board of feeder per building.

Chapter 4

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter presented, analyzes and interpreted the data obtained and corresponding interpretations based on specific questions of the study.

Historical profile of electrical power system

Power consumption for the last eight (8) years

In Figure 5 shows the university energy consumption of electrical power for the last eight (8) years. The energy consumption is increased as to occupancy, addition of infrastructure and laboratory facilities.

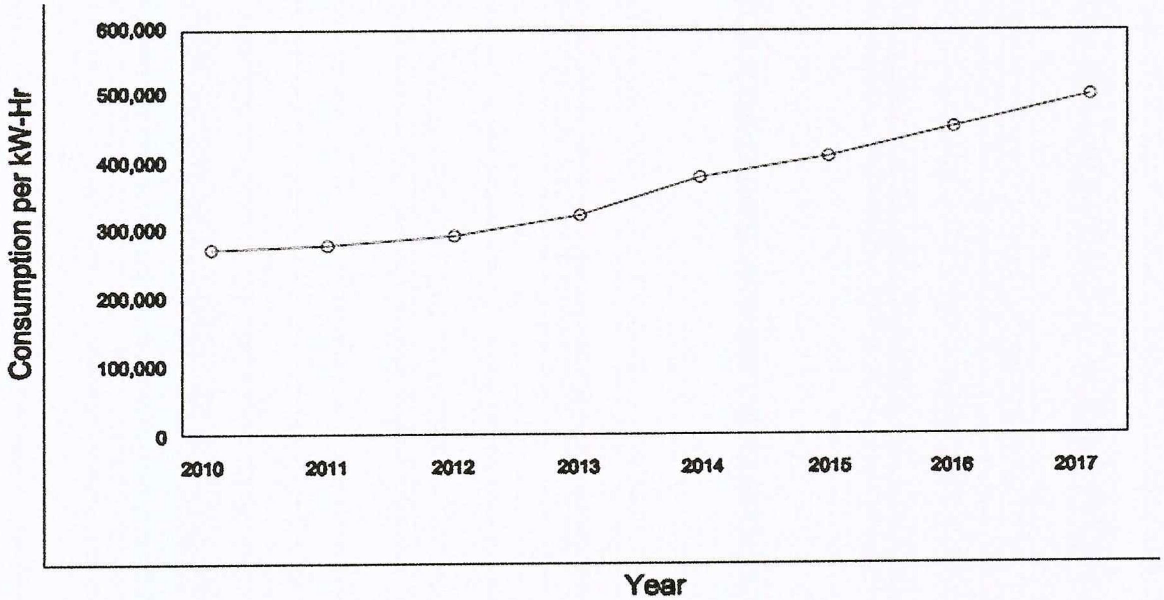
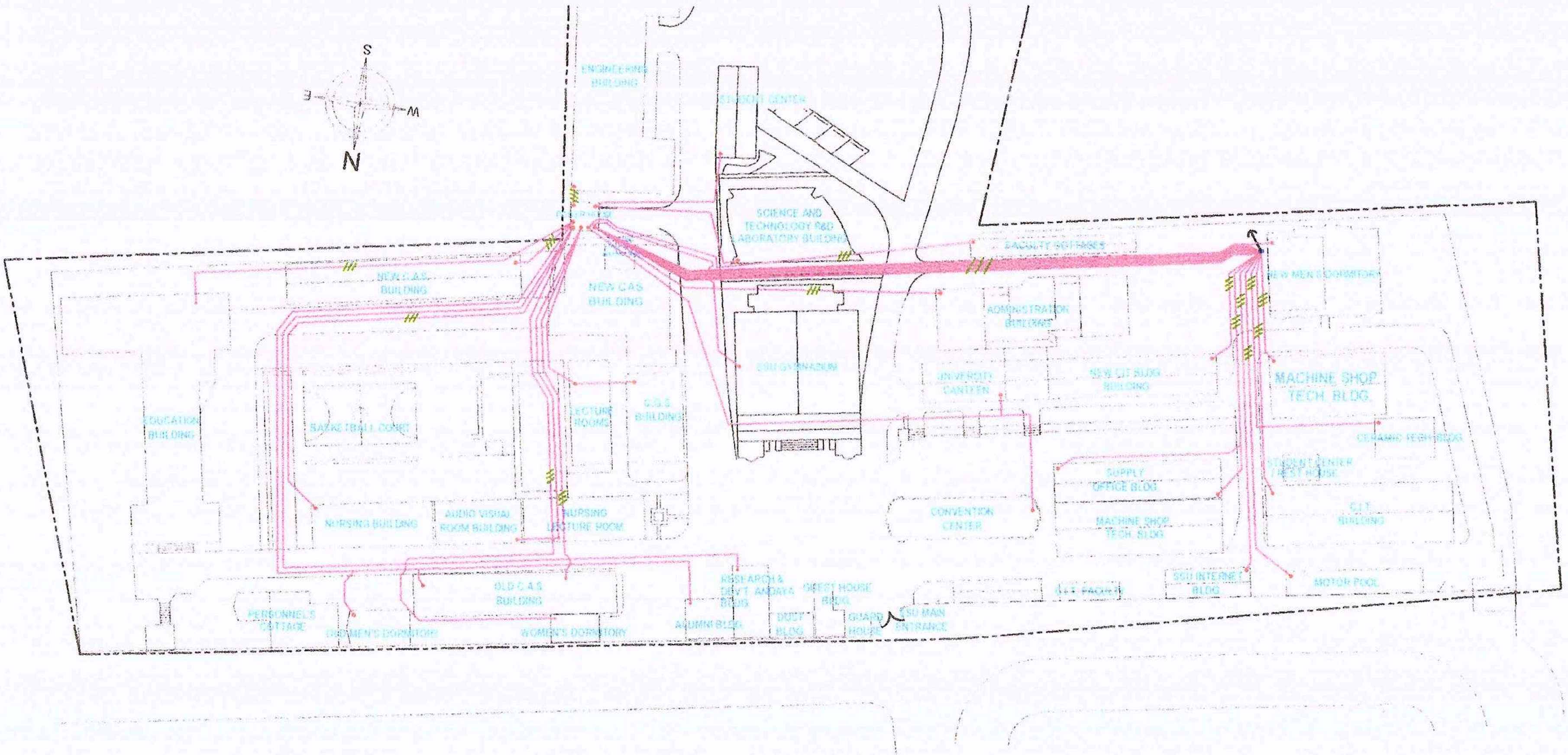


Figure 5 Annual electrical energy consumptions in the last eight (8) years

Existing power distribution per feeder

In figure 4 shows the existing Samar State University electrical feeder distribution.

Figure 4. Existing SSU Electrical Feeder Distribution



In figure 4 above shows the existing power distribution per feeder of the university.

Power system layout

The Samar State University electrical power system structure layout are composes of three sets of pole mounted type distribution transformer and had a rating of 100kVA per phase with a total installed capacity rating of 300kVA. Transformer is bank to derived electrical system to deliver power in secondary thru voltage reduction from 13.2kV systems in primary and 240 volts in secondary. Voltage and current is received thru 3 sets of 3-80.0mm^2 THW copper stranded wire service entrance conductors and protected by 3-2 X 600 amperes cartridge type three pole double throw manual switch panel connecting emergency power from 312 kVA stand-by diesel generator thru 250 ampere trip emergency circuit breaker mains. Starting from three pole double throw panel, 3 sets of 3-80.0 mm^2 THW connected main service disconnect of 1250 amperes distributed power thru main distribution panel. The main distribution panel consisting of seven branch feeder circuit (figure 3) distributed power to respective individual feeder. These seven branch feeders are the following CIT/CON 1ST& 4th floor admin, COED/NCAS, gym, library ACU, admin, old CAS/ R&D guest house, canteen / CGS and engineering respectively. Another an accounted building branch feeder which are mixed along the electrical systems are the electrical two storey building mechanical technology laboratory, new hub building the feeders are tap permanently along four storey college industrial technology building feeder wires.

All of these feeder branches are connected using the bus bar copper main distribution panel connected at upstream and down-stream side of the panel (figure 3). Electrical power system is metered using digital kilowatt-hour meter at secondary or called as secondary metering. There is a grounding conductor in the utility side system but in secondary side of Samar State University electrical loads are not bonded to utilities grounding system or messing. The SSU electrical power system is utilizing a manual cut-out disconnect system controlled and provided by local electric utility company. In figure 3 reflected actual mixed or combination of feeder conductors in one building which resulted to system congestion. Figure 3 below shows the existing University power system layout.

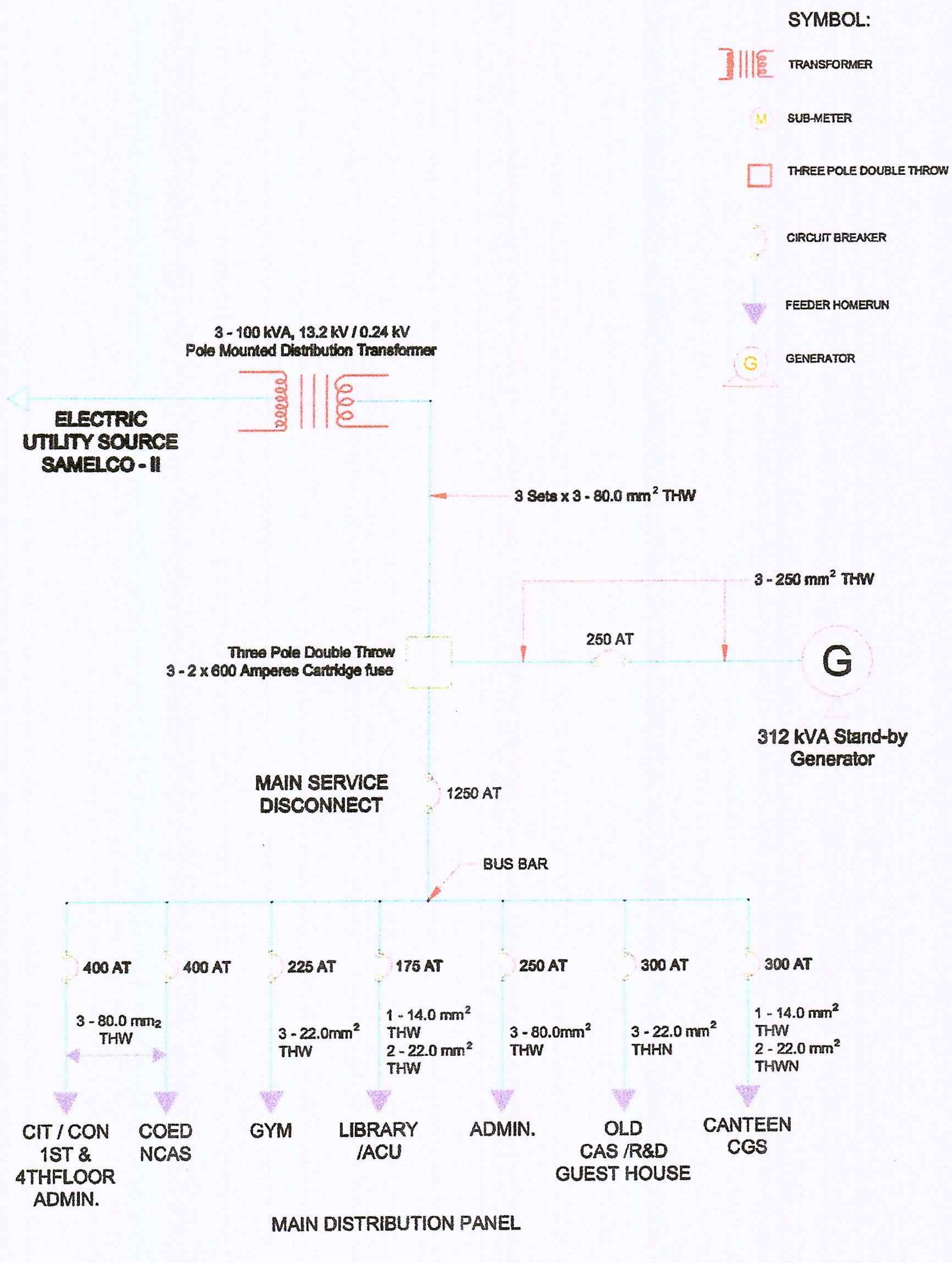


Figure 3. Existing SSU Electrical Power System

In Table 1 are detailed summary of schedule of feeder per building of existing Samar State University electrical power system. Excluded herewith are newly constructed buildings such as college of nursing, convention center, college of industrial technology academic, and men's dormitory building.

Table 1

Schedule of feeder per building

Feeder description	Feeder conductors	Distance from main distribution panel to building
CIT/CON 1^{ST}& 4^{th} floor admin	3-80.0mm^2	315 m , 115m
College of education & NCAS	3-80.0mm^2	127 m, 65 m
Library ACU	1-14.0mm^2, 22.0mm^2	223 m
Administration building	3-80.0mm^2	198 m
Old CAS/ R&D/ guest house	3-22.0mm^2	167,178,198 m
Canteen and graduate studies	2-22.0mm^2 1-14.0mm2	49m, 52m
Engineering building	1-30.0mm^2	74 m
Electrical & mechanical technology building	3-60.0 mm^2	365 m
New hub building	3-38.0 mm^2	388 m

The gymnasium was designed for separate power service or not included in the existing installed power service.

Problems encountered in the power system for the last eight (8) years

In Table 2 below shows the summary of problems in electrical power system derived from experienced of concerned respondents.

Table 2
Problems encountered in Samar State University electrical power systems for the past eight years

Period	Load description	Causes
1988-1997	1. Lightings(ballast type or pre-heated) and power outlets, minor air-conditioning units, arc welding machines and full starting motors 2. Few to moderate motorized loads. Air-conditioning units were utilized for head of departments only and other key personnel.	Starting of inductive loads and capacitive loads Unequal distribution of single phase loads in the three phase systems Uneven distribution of loads to panel or improper distribution of power
1998-2009 2009-present	Increase of air-conditioning units, lighting loads Computers, refrigerators, electric fans, welding machines, turning machines 1. Massive increase of lightings due to infrastructure development projects. Mixed use of electronic lightings, Carbon	Load changes, overload, faults Load exhibiting significant current variations Unequal distribution of single phase loads in the three phase systems Load exhibiting significant current variations

	fluoric lightings (CFL), LED lightings and pre-heated ballast type lightings 2. Un-expected increase use of air-conditioning arc welders, motorized loads, refrigerators, turning machines 3. Provision for Laboratory facilities such as trainers 4. Provision emerging of elevators, fire pump machineries embedded in mechanical systems	Uneven distribution of loads to panel or improper distribution of power Load exhibiting significant current variations

Critical problem encountered in the power system

Overloading - The cascading problem of overloading occurred in selective coordination of electrical power system, resulted to power interruption of Samar State University main campus for a week. This cascaded problem imply that 1250 amperes main circuit breaker remains dormant and in-active by not responding abnormal condition resulted from excess of current in the system. Main circuit breaker should open the system and must protect the transformer unit from damage. This over current failure scenario explained that up to the present, electrical power system has no proper coordination. The administration replaced new transformer for purpose of power restoration in the main campus and equivalent cost of damage was Php 278,250.00 (Appendix 2).

Status of power distribution

Amount of power per building

Lighting

In Table 3 shows lighting load per building and each associated power value per feeder.

Table 3

Lighting power load per building

Feeder description	Office equipment and appliances load (kW)
Administration building	16.761
College of education building	11.838
College of industrial technology	11.366
Two (2) storey electrical & mechanical technology	4.230
Two (2) storey college of graduate studies	3.788
Single storey, old college of arts and sciences	7.045
New college of arts & sciences (CAS) building-1	11.366
College of engineering	10.650
Two (2) storey hub (Internet cafe)	1.332

In table 3 the maximum power load is 67.01 kW, the average value is 7.44 kW and the least value is 1.332 kW. Administration building had the highest lighting load consumption.

Office equipment and appliances

In Table 4 shows office equipment and appliances power load and each associated power per feeder.

Table 4

Office equipment and appliances load per building

Feeder description	Office equipment and appliances load (kW)
Administration building	110.558
College of education building	55.274
College of industrial technology	31.416
Two (2) storey electrical & mechanical technology	15. 694
Two (2) storey college of graduate studies	35.135
Single storey, old college of arts and sciences	24.015
New college of arts & sciences (CAS) building-1	35.710
College of engineering	50.850
Two (2) storey hub (internet cafe)	22.330

In table 4 the maximum power load is 380.982 kW, the average value is 42.331 kW, and the least value is 15.694 kW. Administration building had the highest load power consumption.

Laboratory facilities

In Table 5 shows laboratory facilities load and each associated power value per feeder.

Table 5

Laboratory facilities

Feeder description	Laboratory facilities (kW)
Administration building	0
College of education building	0
College of industrial technology	15.103
Two (2) storey electrical & mechanical technology	15. 694
Two (2) storey college of graduate studies building	0
Single storey, old college of arts and sciences building	0
New college of arts & sciences (CAS) building-1	0
College of engineering	
Two (2) storey hub (Internet cafe)	9.200

In Table 5 the maximum power load is 39.997 kW, the average value is 13.332 kW and the least value is 9.200 kW.

In Table 6 below shows summary power to respective feeder per building. These powers are based in actual recorded of current with the use of digital clamp meter instrument and as-built plans for newly acquired building and existing building in the university. In the table 6 presented the power to each respective building with the records derived from electrical instrument. The full load current calculated with the use of mean formula based from readings per building ampacity at peak loading especially done in the morning between 10:00 AM and 11:00 AM and 2:00 PM to 4:30 PM in the afternoon.

Table 6

Power per building using multi-tester instrument

Feeder description	Amperes				Mean (amperes)
	Morning		Afternoon		
	X_1	X_2	X_3	X_4	$\sum x/n$
CIT/CON	114.3	109.1	119.3	112. 6	113.825
COED/NCAS	162.5	156.4	149.3	151.8	155.0
Administration	296. 5	289.7	277. 6	246.3	277.525
Library ACU	112.7	120.3	119.7	113.3	116.5
Old CAS/R&D,	143.8	146.8	148.3	139.4	144.6
Guest house	98.2	95.8	100.2	98.4	98.1
Canteen & CGS					
Engineering	83.1	85.1	83.8	83.4	83.9

In table 6 shows the total current at 989.45 amperes. The average value is 141.35 amperes, the highest is 277.525 amperes, and the lowest is 83.9 amperes. Administration had the highest load consumption with a value of 277.525 amperes. The engineering had the low load consumer among the group.

In the Table 7 shows the summary of current reading of individual feeder delivered and the corresponding calculated power going to the loads namely Old CAS/R&D, guest house, canteen & CGS, and engineering building respectively.

Table 7

Power distributed to respective building using digital clamp-on multi-tester and full load current from as-built plan

Feeder Description	amperes	Volts	Power (kW)
CIT/CON	113.825	230	36.274
COED/NCAS	115	230	36. 649
Administration	277.525	230	88.443
Library ACU	116.5	230	37.127
Old CAS/R&D, guest house	144.6	230	57.602
Canteen & CGS	98.1	230	31.263
Engineering	83.9	230	26.737
Sub-total 1	**949.45**		**314.059**
Convention center	508.168	230	161.947
Science & technology and research center	573.312	230	182.707
Men's dormitory	188.658	230	60.123
CIT academic building	277.263	230	110.450
College of nursing	236.06	230	75.229

In the table 7 existing power loads had a value of 314.059 kW. Additional infrastructure building had a value of 590.456 kW. The total loads including the existing and the new acquired building had a value of 904.515 kW.

In the table 8 shows the total power load per building from actual existing loads.

Table 8
Distribution of total power per building

Feeder description	Volts	Power (kW)	Amperes
Administration	230	127.319	399. 509
College of education	230	67.112	210. 588
College of industrial technology (4) storey building)	230	57.885	181. 635
Two (2) storey electrical & mechanical technology	230	47.622	149. 556
Two (2) storey college of graduate studies	230	38.923	122.135
Single storey, old college of arts and sciences	230	31.060	97.462
New college of arts & sciences (CAS) buildin-1	230	47.076	147.718
Four (4) storey college of engineering building	230	61.500	192.978
Two (2) storey hub (internet cafe)	230	23.662	74.248

In the table 8 existing power loads had a value of 502.149 kW. The average load is 55.794 kW. The highest load in the group is 127.319 kW; the lowest load is 23.662 kW. Administration building had the highest load consumption with a value of 127.319 kW. The Internet cafe had the low load consumer among the group. Total current value is 1575.829 amperes.

In table 9 below shows the comparative summary of result derived from actual loading to existing SSU electrical power system.

Table 9

Comparison of result from actual calculated loading to existing electrical power system.

Computed Loading	Existing SSU electrical power system
627.747 kVA @ 209 kVA per phase	300 kVA @ 100 kVA per phase
2 sets of 3-200.0 mm^2	3 sets of 3-80.0 mm^2
2,000 Amperes	1,250 Amperes

In table 9 shows the significant discrepancy in selective coordination problem of Samar State University existing electrical power system to achieve optimized power system performance. All components are under rated in each parametric desired loading capacity.

Power system infrastructure

Physical status of power system infrastructure

First Private Pole

The design of the structure (Appendix 3) is feed by the cut-out type principles of operation. Power is manually operated and continuously energize at 13,200 volts. The system is dependent to electric cooperative. This type of design is superseded because the Philippines are exposed to natural calamities. Also, this design has no provision for electrical maintenance and repair for replacement of its associated facilities and protections such as transformer, circuit breaker and service entrance conductors. Also, system is not accessible for isolation from hazard of electricity in event of natural calamity or emergency.

Transformer

Transformer received power (Appendix 4) from utility and lower high voltage to accommodate 230 volts requirement. Actual setting of the system has lacking part for transformer protection. This device called Current Limiting Fuse (CLF) that protects the transformer unit from fault or short circuit. These CLF is missing in the system. Rated per phase is 100kVA and had a total of 300kVA capacity.

Service Entrance Conductor

Service entrance conductors (Appendix 5) received power from secondary of transfer at 230 volts. The 3 sets of 3-80.0 mm^2 THW stranded are the sizes of the service entrance conductors and installed in secondary side of transformer and transfer it to the respective loads of the school buildings

Manual Transfer Switch

Manual transfer switch (Appendix 6) has a rating of 2-600 amperes per phase and this type of fuse is fixed and replaceable. The existing two pairs of fuse in the left part showing de-colorization. Today, most of the transfer switches are utilizing circuit breaker components such as manual transfer breaker type of design with adjustable setting that suited the requirements of the loading compatible to the needs of the end-user. The advantage of circuit breaker type is that it can easily be check for maintenance purposes unlike fuse it is hidden inside the filament mechanism.

Main Service Disconnect

Main service disconnect (Appendix 7) has a rating of 1,250 amperes three (3) pole, three phase that carry all the loads of the power systems and opens the systems in the event of fault, overloading and the largest circuit breaker in the system.

Main Distribution Panel

Main distribution panel (Appendix 8) distributed power to respective feeder. This is where common point of connection of the feeder circuits in which is need of enhancement emphasis because it has no vacant space for the new acquired structures.

Feeder Circuit Breakers

Feeder circuit breaker (Appendix 9) of power system protects the individual buildings. This area is in need of re-design in order to have safety access for personnel performing maintenance works.

Feeder Conductors

This area should be given an extra emphases in the improvement of handling energize cable or wires which are delivering power to respective buildings and apply appropriate raceways or closed channel to protect wires from natural and physical disturbances. Feeder conductor (Appendix 10) carried current to individual building.

Status of existing power system infrastructure based on selective coordination in kilo-ampere interrupting capacity (KA) of circuit breaker

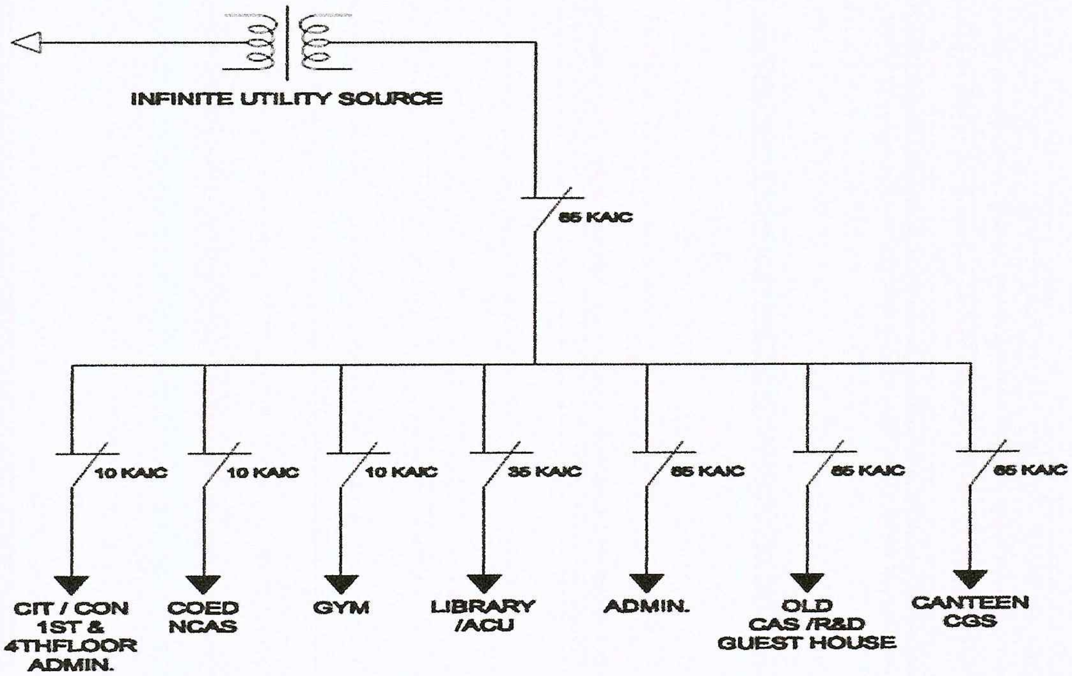


Figure 6 existing selective coordination of power system

As reflected in Figure 6 above, highest value of existing circuit breaker is 65 KA at 240 volts (Appendix 15), derived from main circuit breaker and administration building (Appendix 16).

Design of power distribution system

Peak current consumption of the present system

The present electrical power system covers the existing building and newly acquired building that is ready for occupancy and in the stage of completion. The table 10 summarized the details of building and current consumption per feeder.

Table 10

Distribution of power including the new building

Feeder Descriptions	Amperes	Power (kW)
Administration building	399. 509	127.319
College of education building	210. 588	67.112
College of industrial technology (4) storey building	181. 635	57.885
Two (2) storey electrical & mechanical technology building	149. 556	47.622
Two (2) storey college of graduate studies building	122.135	38.923
Singe storey, old college of arts and sciences building	97.462	31.060
New college of arts & sciences (CAS) building -1	147.718	47.076
Four (4) storey college of engineering building	192.978	61.500
Two (2) storey hub (internet café) building	74.248	23.662
Convention center	508.168	161.947
Science & technology and research center	573.312	182.707
Men's dormitory	188.658	60.123
CIT academic building	277.263	110.450
College of nursing building	236.06	75.229

In table 10 the present maximum peak current load is 3,359.29 amperes. The average current is 239.949 amperes. The lowest current value is 74.248 amperes.

Power System Infrastructure

In Table 11 shows the new power system infrastructure based from actual computed load.

Table 11

Power System Infrastructure

Bus	Load	Rating
Transformer	1070. 565	1000 kVA
Service entrance conductor	1119.763	3 sets of 4-250.0 mm^2
Main service disconnect	3,359.29	3,500 AT

In Table 11 above shows the power system infrastructure needed in the new Samar State University electrical power system.

In Table 12 shows the specific sizes of feeder wires for new electrical power system structures per building.

Table 12

Summary of sizes of feeder conductor and circuit breakers per building

Feeder descriptions	Circuit breaker	Sizes of Wire and Grounding conductor
Administration building	300AT	3-100.0 mm^2 + 1-22.0 mm^2
College of education building	175AT	3-38.0 mm2 + 1-22.0 mm^2
College of industrial technology (4)-storey building	150AT	3-38.0 mm2 + 1-22.0 mm^2
Two (2) storey electrical and mechanical technology building	125AT	3-38.0 mm2 + 1-22.0 mm^2
Two (2) storey college of graduate studies building	100AT	3-38.0 mm2 + 1-22.0 mm^2
Single storey, old college of arts and sciences building	75AT	3-22.0 mm2 + 1-22.0 mm^2

New college of arts and sciences (CAS) building -1	100AT	3-38.0 mm2 + 1-22.0 mm^2
Four (4) storey college of engineering building	175AT	3-60.0 mm2 + 1-30.0 mm^2
Two (2) storey hub (internet cafe) building	75AT	3-22.0 mm2 + 1-30.0 mm^2
Convention center	800AT	3 sets of 2-150.0 mm2 + 1-80.0 mm^2
Science & technology and research center	600AT	3 sets of 2-150.0 mm2 + 1-50.0 mm^2
Men's dormitory building	225AT	3-100.0 mm2 + 1-50.0 mm^2
CIT academic building	250AT	3-150.0 mm2 + 1-50.0 mm^2
College of nursing building	250AT	3-125.0 mm2 + 1-50.0 mm^2

In table 12 shows the rated sizes of circuit breaker and feeder conductors of the new electrical power system.

Design analysis for new SSU Electrical power system

Voltage drop calculation per building

In Table 13 shows the voltage drop calculation per building. In the real practice, it is very rare that the percent voltage drop exceeded 5%. It means that the existing electrical power system delivers power at very low voltage due to long distance of buildings (figure 4).

Table 13

Voltage Drop Calculation per building

Feeder Descriptions	Wire Size/Phase	Resistance Per 305 m	Reactance Per 305 m	Length (m)	load	Vd	% Vd	Voltage @ panel
Administration building	3-100.0 mm^2	0.063	0.051	198	319. 6	16.8	7.3	213.18
College of education	3-38.0 mm^2	0.16	0.057	127	168.4	11.9	5.18	224.82
College of industrial technology (4) four storey building	3-38.0 mm^2	0.16	0.057	315	145.3	25.3	11.0	204.38

Two (2) storey electrical & mechanical technology building	3-38.0 mm^2	0.16	0.057	365	119.5	24.2	10.5	205.72
Two (2) storey college of graduate studies	3-38.0 mm^2	0.16	0.057	52	97.7	2.82	1.23	227.17
Single storey, old college of arts and sciences building	3-22.0 mm^2	0.060	0.31	167	77.9	13.4	5.86	216.52
New college of arts and sciences building 1	3-38.0 mm^2	0.16	0.057	65	118.1	4.27	1.85	225.72
Four (4) storey college of engineering building	3-60.0 mm^2	0.10	0.054	74	154.3	4.25	1.84	252.74
Two (2) storey hub (internet café)	3-22.0 mm^2	0.060	0.31	388	59.3	23.4	10.2	206.53
Convention center	3-150.0 mm^2	0.045	0.051	217	508.1	24.5	10.6	205.41
Science & technology and research center	3-150.0 mm^2	0.045	0.051	49	573.3	6.26	2.7	223.73
Men's dormitory	3-100.0 mm^2	0.063	0.051	372	188.6	18.4	8.0	211.30
CIT academic building	3-150.0 mm^2	0.045	0.051	244	277.2	15.0	6.5	214.91
College of nursing building	3-125.0 mm^2	0.054	0.052	277	236.0	16.0	6.9	213.92

In table 13 shows the value of voltage drop based on actual loading. The highest is 11.026 percent; the lowest is 1.23 percent.

In Figure 7 below shows impedance diagram of the new SSU electrical power system starting from each respective buses. Design in common point of fault in bus-bar of administration and education building.

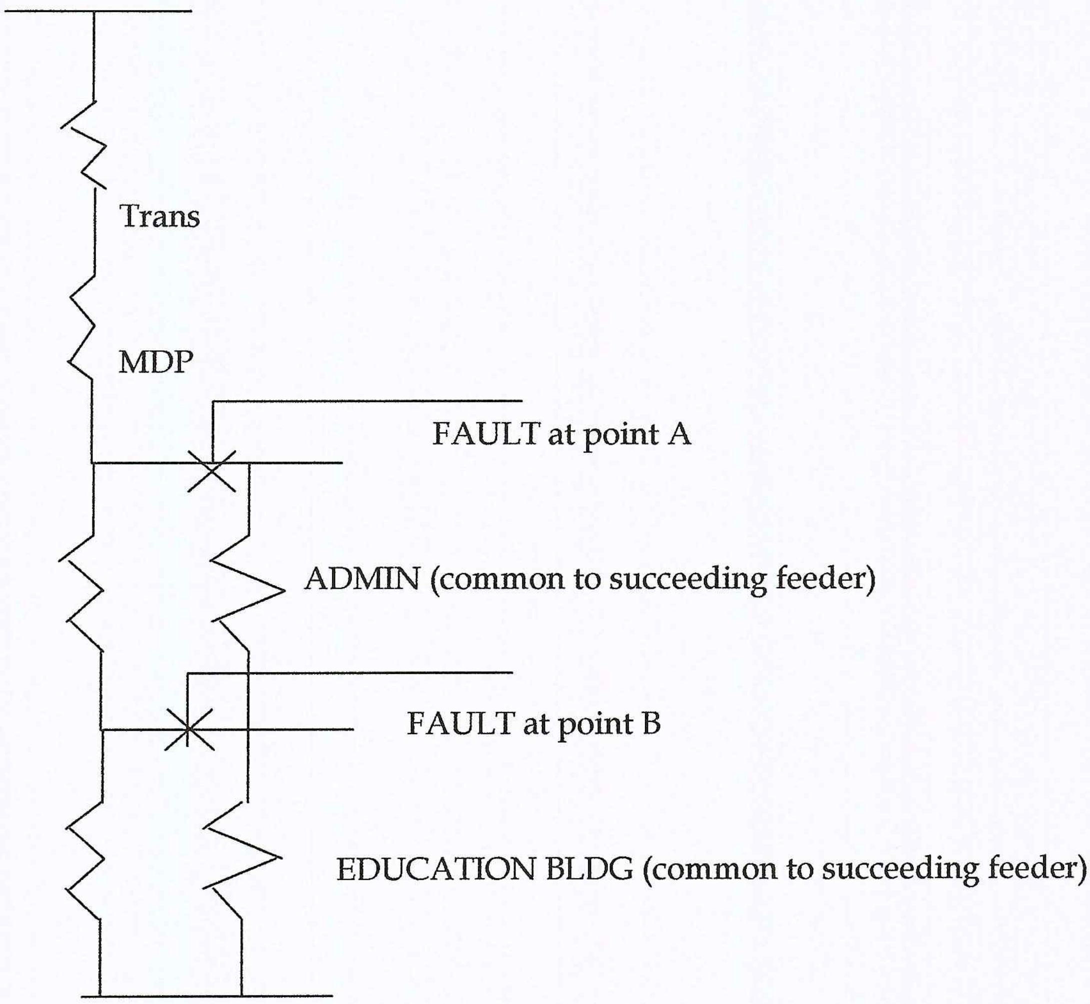


Figure 7 impedance diagram of the new SSU electrical power System

In Table 14 shows resistance, reactance and impedance for short circuit calculation.

Table 14

Summary of resistance, reactance and impedance for short circuit calculation

Common to all feeders

Bus	Wire Size/ Phase	Resistance, Ohms per 305 m	Reactance, ohms per 305 m	Length (m)	Total resistance	Total reactance	Impedance	pu Z
Transformer								0.032
MDP	4-250.0 mm^2	0.029	0.048	20	0.00190	0.00314	0.00367	0.083
Administration building	3-100.0 mm2	0.063	0.051	198	0.0408	0.03310	0.05253	1.191
College of education building	3-38.0 mm2	0.16	0.057	127	0.0666	0.0237	0.07069	1.603

Table 15

Comparison of (kA) rating of circuit breaker for selective coordination

In Table 15 shows comparison of (kA) rating of selective coordination

Bus	Load	Existing (KA) rating	Computed load
Administration (Fault -1)	28,743.803	65	28
College of education (Fault-2)	15,584.617	15	10

In Table 15, the existing KA rating of Administration building (Appendix 12) is oversized. Rated size is 28 KA; college of education (Appendix 11) is undersized; rating size is 15 KA.

Power Service

The new Samar State University electrical power system should be designed in to two separate types of power service.

Total power cost

Baseline power in kilowatt-hour per year using 239.949 amperes mean value is Php 8,038,407.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions and recommendations of the study.

Summary of findings

On the bases of data collected, organized and analyzed, the following are salient findings of the study:

1. Power consumption of the university increased in the last eight (8) years starting from year 2010 up to 2017. The maximum connected load utilized is equivalent to 2,767, 680 kW-Hr, average is 345,960 kW-Hr and the lowest is 287, 600 kW-Hr.
2. Over loading is the core problem in Samar State University electrical power system for the past eight (8) years. Administration replaced the damage transformer, the potential cost of damage was Php 278,250.00
3. The power loading of electrical system reached up to 1,070. 565 kW in total.

   3.1 lighting load: maximum power load is 67.01kW, the average value is 7.44kW, and the lowest is 1.33 kW. Administration building had the highest lighting load consumption.

   3.2 office equipment and appliances: maximum load is 380.98 kW, the average value is 42.33 kW, and the lowest is 15. 69 kW.

Administration building had the highest load power consumption.

3.3 laboratory facilities: maximum power load is 39.99 kW, the average value is 13.33 kW and the lowest is 9.20 kW. Electrical & mechanical technology building had the highest load power consumption.

4. The power system infrastructure namely, main distribution panel of the power system cannot be used for any additional feeder or building, which is already congested. The electrical system has a failure in selective coordination in terms of its KA rating of circuit breakers supplying power per buildings. The voltage lowers as the power supply extends far from the power house to the point of service of the building. The voltage drop per building has a higher value of up to 11% in the system. The existing rating of transformer of electrical power system is under size including its main service disconnects, respective feeder conductors and circuit breakers.

4.1 peak current consumption of the present system: Maximum current load is 3,359.29 amperes. The average current is 239.949 amperes. The lowest current value is 74.248 amperes.

4.2 power system infrastructure: is in need to enhanced of sizes from 1250 amperes to 3,500 amperes in main disconnect and the service entrance conductor is needed to be resize from 3 sets of 3-80.0 mm2 TW/THW to 3 sets of 4-250.0 mm2 THWN.

Conclusions

Based on the findings of the study just presented, the following conclusions are drawn:

1. The increase of energy consumption of the university should be considered as one of the indicators for electrical system enhancement.
2. Electrical over loading is a recurring problem in the electrical system as a result of load expansion. Electrical system is in state of active failure.
3. Existing power system infrastructure has no selective coordination in terms of rated loading capabilities. In general, electrical system is under rated or under size starting from transformer, circuit breakers, service entrance conductors and feeders.
4. The peak current loading reached up to 3,359.29 amperes. Transformer rated sized at 1,000 kVA.

Recommendations

In the light of the findings and conclusions evolved in this study, and based on the possibility of the innovative approaches derived from the respondents and electrical design analysis, the researcher recommends the following to enhance the selective coordination of university electrical power system.

1. Enhancement of Samar State University electrical power system are needed starting from first private pole, transformer up to branch feeder circuit supplying per building.
2. Provision of separate power service due to higher voltage drop percentage of the existing buildings is necessary.

Chapter 6

PROPOSED ENHANCEMENT OF SELECTIVE COORDINATION FOR SAMAR STATE UNIVERSITY ELECTRICAL POWER SYSTEM

This chapter presented the proposed design for Samar State University electrical power system.

Rationale

Enhancement of selective coordination for Samar State University electrical power system study is necessary because of continuous expanding and addition of institutional building in the main campus. Technical engineering solution is counterpart in future institutional planning especially in the utilization of infrastructures.

Description

The study entails to upgrade the existing electrical power system covered the coordination and selectivity of transformers, service entrance conductors, feeder conductors, and circuit breaker.

Objectives

The objective of the study is to design power distribution system based on findings, recommendation, and conclusion.

1. Implementation Plan

   1.1 Power plot plan

   1.2 Material and budgetary requirement plan

Power plot plan

In figure 8 are the new proposed enhancement of existing electrical power system. The power components are first private pole, transformer, low voltage switchgear, individual metering per building and the replacement of new feeder conductors and circuit breaker. Figure 9 shows the rehabilitation of existing university electrical power system and figure 10 shows the proposed new electrical feeder distribution.

Material and budgetary requirement plan

This section represented the material needed in enhancement of electrical power system.

Primary metering and material description	Cost Estimate	
1. CT, 15kV	1 lot	48,000.00
2. PT, 15kV	1 lot	38,000.00
3. UNI-RUPTER 15kV	1 lot	12,000.00
4. 3-XLPE @15kV 50mm^2 conductor	100 m	140,000.00
5. 3-300kVA distribution type transformer	1 lot	1,300,000.00
6. First private pole including accessories	1 lot	1,130,000.00
7. Low voltage switchgear	1 lot	4,000,000.00
8. Sub-secondary panel board metering	1 lot	300,000.00
9. Wires and conductors	1 lot	3,000,000.00
10. Circuit breakers and protections	1 lot	1,300,000.00
Total Cost:	**Php 10,968,000.00**	

Figure 8 shows proposed new separate power service.

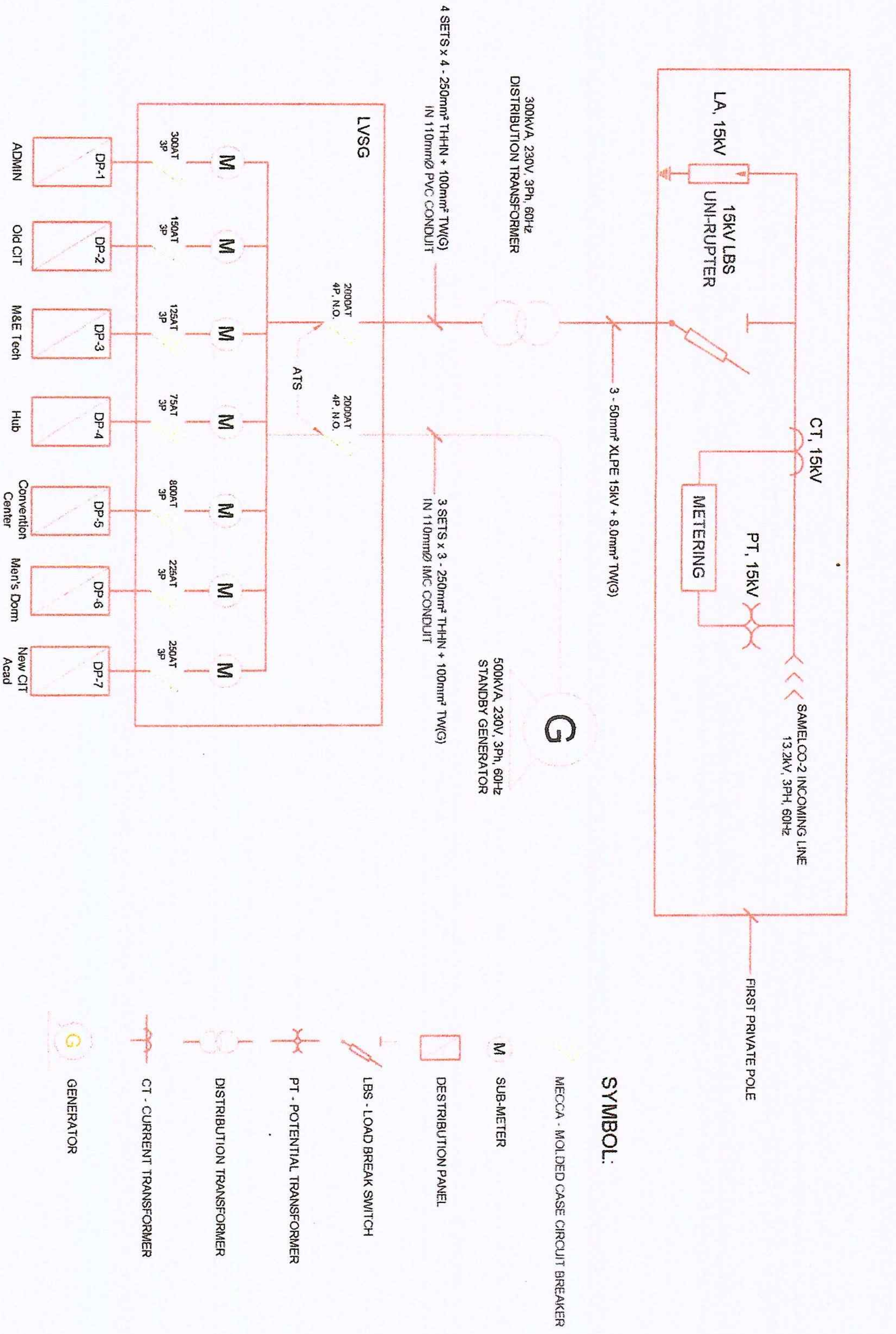
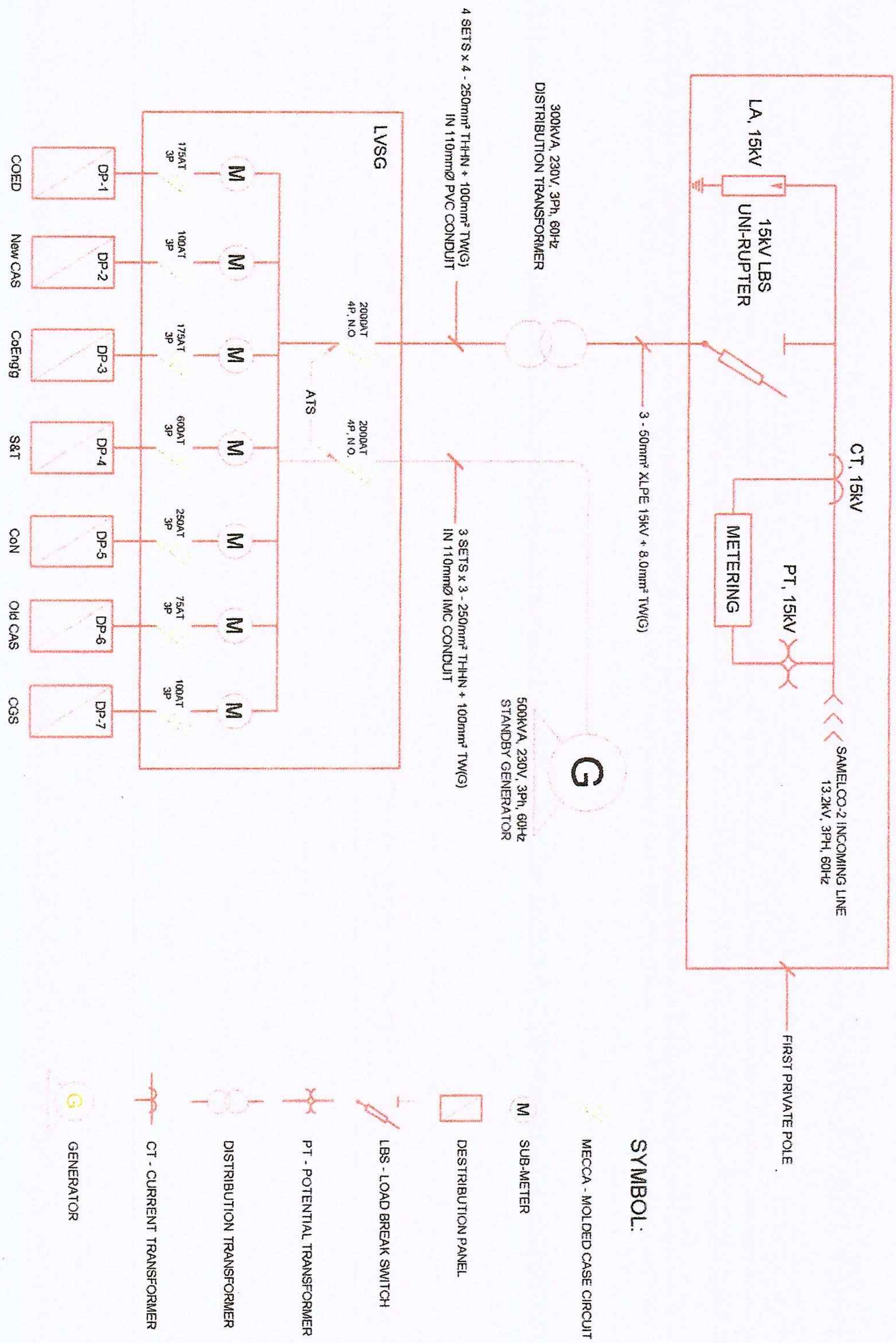
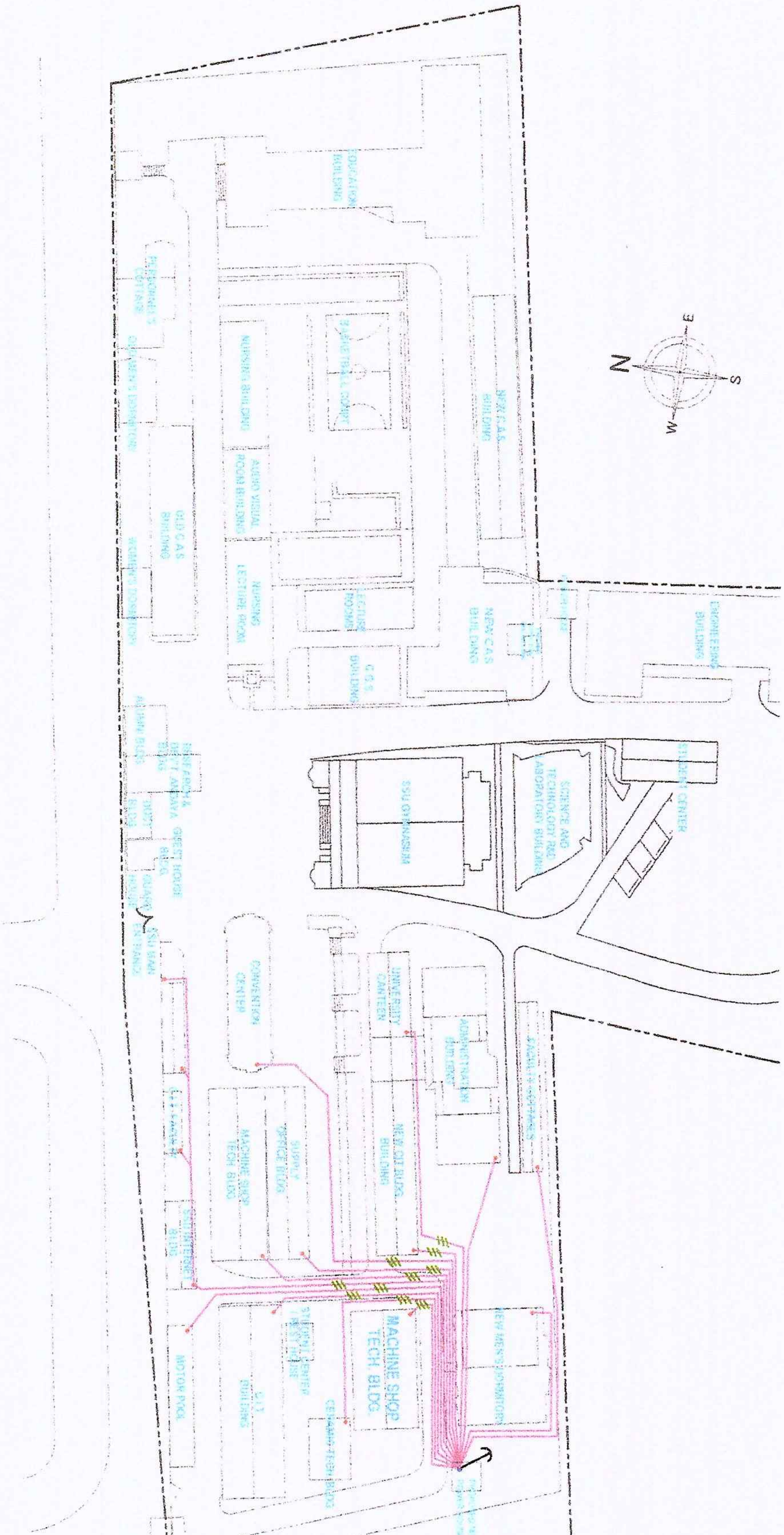


Figure 8. Proposed new separate power service

Proposed plan for enhancement of existing power service (Figure 9)





ENGINEERING BUILDING
STUDENT CENTER
SCIENCE AND TECHNOLOGY R&D LABORATORY BUILDING
NEW C.A.S. BUILDING
NEW C.A.S. BUILDING
SSU GYMNASIUM
EDUCATION BUILDING
BASKETBALL COURT
LECTURE ROOMS
G.S. BUILDING
NURSING BUILDING
AUDIO VISUAL ROOM BUILDING
NURSING LECTURE ROOM
OLD C.A.S. BUILDING
PERSONNEL'S COTTAGE
WOMEN'S DORMITORY
ALUMNI BLDG
GUEST HOUSE BLDG.
GUARD HOUSE
SSU MAIN ENTRANCE
FACULTY COTTAGES
ADMINISTRATION BUILDING
UNIVERSITY CANTEEN
NEW CIT BLDG. BUILDING
NEW MEN'S DORMITORY
MACHINE SHOP TECH. BLDG.
CERAMIC TECH BLDG
SUPPLY OFFICE BLDG.
MACHINE SHOP TECH. BLDG.
CONVENTION CENTER
C.I.T. BUILDING
MOTOR POOL
N
S
E
W

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APPENDECES

APPENDIX 1

SSU Three (3) phase power bill

SAMAR II ELECTRIC COOPERATIVE, INC
Paranas, Samar

ccount No : 01100110

Name : SAMAR STATE POLYTECHNIC COLLEGE

Address : GOV`T OFFICE

Area / Book : 001 / 010

Rate Type : Public

Serial : 28-085-309

ng	Previous	Present	kwhr	TotalBill	Paid	Bill No.	Paid Date	OR #	Teller
7	52,967	53,463	39,680	377,192.72	No				
7	52,486	52,967	38,480	319,880.73	Yes	1929576	2017-11-21	269849	Kathleen Claire M. Rarugal
7	51,866	52,486	49,600	430,377.18	Yes	1893401	2017-10-24	280125	Kathleen Claire M. Rarugal
7	51,409	51,866	36,560	341,852.74	Yes	1856634	2017-09-20	274180	DBP
7	51,158	51,409	20,080	185,112.48	Yes	1818111	2017-09-04	273578	DBP
7	50,711	51,158	35,760	328,347.08	Yes	1809453	2017-08-09	272934	DBP
7	50,246	50,711	37,200	349,399.58	Yes	1785911	2017-07-05	270947	DBP
7	49,888	50,246	28,640	285,416.88	Yes	1735277	2017-06-06	271881	DBP
7	49,347	49,888	43,280	437,846.02	Yes	1694738	2017-05-03	271016	DBP
7	48,894	49,347	36,240	367,665.55	Yes	1643531	2017-03-30	264563	DBP
7	48,351	48,894	43,440	429,204.38	Yes	1632737	2017-02-28	263693	DBP
6	47,991	48,351	28,800	295,001.81	Yes	1273956	2017-01-27	262893	DBP
6	47,496	47,991	39,600	365,054.34	Yes	1511546	2017-01-05	262214	Leah C. Tabuzo
6	47,049	47,496	35,760	332,555.58	Yes	1480674	2016-12-09	261644	Kathleen Claire M. Rarugal
6	46,431	47,049	49,440	457,304.99	Yes	1398073	2016-11-03	260585	Kathleen Claire M. Rarugal
6	45,844	46,431	46,960	448,254.73	Yes	1398070	2016-11-03	260585	Kathleen Claire M. Rarugal
6	45,291	45,844	44,240	419,015.96	Yes	1354748	2016-09-01	254106	DBP
6	44,803	45,291	39,040	344,359.65	Yes	1341758	2016-08-09	252598	DBP
6	44,398	44,803	32,400	299,819.13	Yes	1268944	2016-07-12	251987	DBP
6	43,978	44,398	33,600	328,751.53	Yes	1293430	2016-06-07	245975	DBP
6	43,617	43,978	28,880	295,927.78	Yes	1201605	2016-05-04	243814	DBP
6	43,242	43,617	30,000	300,449.62	Yes	1163449	2016-03-31	243007	DBP
6	42,779	43,242	37,040	314,937.59	Yes	1134116	2016-03-04	241319	DBP
5	42,452	42,779	26,160	234,643.50	Yes	1009205	2016-02-10	240745	DBP
5	42,151	42,452	24,080	211,148.34	Yes	1088892	2016-01-12	208396	Leah C. Tabuzo
5	41,512	42,151	51,120	451,296.82	Yes	0967632	2015-12-01	218793	Kathleen Claire M. Rarugal
5	40,873	41,512	51,120	464,532.40	Yes	0966850	2015-11-12	211559	Kathleen Claire M. Rarugal
5	40,340	40,873	42,640	379,151.53	Yes	0909243	2015-10-01	192245	DBP
5	39,917	40,340	33,840	305,468.53	Yes	0894402	2015-08-28	187727	DBP
5	39,301	39,917	49,280	454,558.00	Yes	0832120	2015-08-03	187283	Kathleen Claire M. Rarugal
5	38,890	39,301	32,880	297,437.02	Yes	0820195	2015-07-02	186682	Kathleen Claire M. Rarugal
5	38,532	38,890	28,640	281,584.42	Yes	0769294	2015-06-02	186108	Kathleen Claire M. Rarugal

ng	Previous	Present	kwhr	TotalBill	Paid	Bill No.	Paid Date	OR #	Teller
5	38,247	38,532	22,800	214,468.45	Yes	0760966	2015-04-30	185496	Lady Dianne Lobriño
5	37,935	38,247	24,960	235,812.95	Yes	0673263	2015-03-31	184290	Kathleen Claire M. Rarugal
5	37,534	37,935	32,080	264,235.66	Yes	0663968	2015-03-11	183879	Leah C. Tabuzo
4	37,350	37,534	14,720	122,618.38	Yes	0599168	2015-02-16	183459	Leah C. Tabuzo
4	37,056	37,350	23,520	187,718.39	Yes	0558753	2015-01-09	179144	Leah C. Tabuzo
4	36,723	37,056	26,640	200,462.81	Yes	0543978	2014-12-15	178938	Kathleen Claire M. Rarugal
4	36,254	36,723	37,520	398,497.60	Yes	0589505	2015-01-23	179467	Leah C. Tabuzo
4	35,834	36,254	33,600	297,200.46	Yes	0497810	2014-10-01	175564	Kathleen Claire M. Rarugal
4	35,402	35,834	34,560	293,672.21	Yes	0453919	2014-09-03	174469	Kathleen Claire M. Rarugal
4	35,079	35,402	25,840	238,255.92	Yes	0432621	2014-08-01	172480	Kathleen Claire M. Rarugal
4	34,582	35,079	39,760	331,903.59	Yes	0420926	2014-06-30	175455	Charlene V. Potol
4	34,390	34,582	15,360	148,463.03	Yes	0323722	2014-06-04	142449	Kathleen Claire M. Rarugal
4	34,171	34,390	17,520	172,752.79	Yes	0314518	2014-05-05	138478	Kathleen Claire M. Rarugal
4	33,862	34,171	24,720	255,339.62	Yes	0314516	2014-05-05	138478	Kathleen Claire M. Rarugal
4	33,535	33,862	26,160	267,983.25	Yes	0224852	2014-03-06	138967	Kathleen Claire M. Rarugal
3	33,333	33,535	16,160	146,945.29	Yes	0168001	2014-02-06	138490	Kathleen Claire M. Rarugal
3	33,247	33,333	6,880	60,679.11	Yes	0159659	2014-02-05	138478	Kathleen Claire M. Rarugal
3	33,097	33,247	12,000	104,023.40	Yes	133497	2014-01-06	136497	Kathleen Claire M. Rarugal
3	32,710	33,097	30,960	261,434.39	Yes	0117599	2013-12-03	136199	Leah C. Tabuzo
3	32,260	32,710	36,000	306,612.97	Yes	0068660	2013-10-31	112535	Kathleen Claire M. Rarugal
3	31,927	32,260	26,640	223,157.74	Yes	0049806	2013-09-24	111965	Leah C. Tabuzo
3	31,499	31,927	34,240	293,950.69	Yes	0001215	2013-09-04	111666	Kathleen Claire M. Rarugal
3	31,107	31,499	31,360	269,465.05	Yes	0005506	2013-08-13	111272	Leah C. Tabuzo
3	30,827	31,107	22,400	197,564.86	Yes	3470734	2013-07-09	106576	Kathleen Claire M. Rarugal
3	30,545	30,827	22,560	196,172.98	Yes	3463256	2013-06-06	106005	Leah C. Tabuzo
3	30,228	30,545	25,360	212,500.28	Yes	3391039	2013-05-03	100820	Kathleen Claire M. Rarugal
3	29,888	30,228	27,200	230,013.32	Yes	3339609	2013-04-05	100364	Kathleen Claire M. Rarugal
2	29,514	29,888	29,920	253,488.44	Yes	3335485	2013-02-26	99764	Leah C. Tabuzo
2	29,252	29,514	20,960	177,462.52	Yes	3096921	2013-02-05	99361	Kathleen Claire M. Rarugal
2	28,863	29,252	31,120	254,629.52	Yes	3093819	2013-01-16	96963	Kathleen Claire M. Rarugal
2	28,578	28,863	22,800	198,256.28	Yes	3062951	2012-11-29	96309	Kathleen Claire M. Rarugal
2	28,244	28,578	26,720	266,054.56	Yes	3001752	2012-10-29	94692	Kathleen Claire M. Rarugal
2	27,941	28,244	24,240	217,760.59	Yes	3001751	2012-10-29	94692	Kathleen Claire M. Rarugal
2	27,572	27,941	29,520	251,144.15	Yes	2954194	2012-08-31	90870	Kathleen Claire M. Rarugal
2	27,216	27,572	28,480	215,972.96	Yes	2904552	2012-07-26	90430	Leah C. Tabuzo
2	26,933	27,216	22,640	168,945.41	Yes	2904551	2012-07-26	90430	Leah C. Tabuzo
2	26,658	26,933	22,000	177,277.12	Yes	2856346	2012-06-05	87715	Leah C. Tabuzo
2	26,396	26,658	20,960	161,816.21	Yes	2844540	2012-05-04	87237	Leah C. Tabuzo
2	26,161	26,396	18,800	140,087.05	Yes	2842112	2012-04-17	86991	Leah C. Tabuzo
1	25,856	26,161	24,400	188,064.27	Yes	2770830	2012-02-23	86325	Leah C. Tabuzo
1	25,521	25,856	26,800	199,662.40	Yes	2760409	2012-02-09	86161	Leah C. Tabuzo
1	25,178	25,521	27,440	202,863.24	Yes	2739850	2012-01-10	84770	Leah C. Tabuzo
1	24,943	25,178	18,800	151,827.81	Yes	2734172	2011-12-06	82485	Leah C. Tabuzo
1	24,526	24,943	33,360	284,138.47	Yes	2602821	2011-10-28		
1	24,125	24,526	32,080	270,576.94	Yes	2574115	2011-09-28		
1	23,838	24,125	22,960	195,056.28	Yes	2544001	2011-08-31		

ng	Previous	Present	kwhr	TotalBill	Paid	Bill No.	Paid Date	OR #	Teller
1	23,475	23,838	29,040	230,081.20	Yes	2516875	2011-08-01		
1	23,254	23,475	17,680	140,853.78	Yes	2490674	2011-07-01		
1	23,014	23,254	19,200	150,462.33	Yes	2462864	2011-05-30		
1	22,750	23,014	21,120	158,113.63	Yes	2449174	2011-05-09		
1	22,566	22,750	14,720	112,393.11	Yes	2418092	2011-04-06		
0	22,246	22,566	25,600	194,481.26	Yes	1989036	2011-03-16		
0	21,929	22,246	25,360	190,705.42	Yes	1989029	2011-01-11		
0	21,612	21,929	25,360	191,302.19	Yes	1980787	2010-12-29		
0	21,386	21,612	18,080	138,085.10	Yes	1951114	2010-12-06		
0	21,012	21,386	29,920	247,492.59	Yes	1921054	2010-11-05		
0	20,660	21,012	28,160	214,151.69	Yes	1884612	2010-10-05		
0	20,337	20,660	25,840	198,850.34	Yes	1847112	2010-09-01		
0	19,927	20,337	32,800	257,085.51	Yes	1820883	2010-07-23		
0	19,605	19,927	25,760	207,453.51	Yes	1781558	2010-07-05		
0	19,390	19,605	17,200	132,564.58	Yes	1750497	2010-06-08		
0	19,172	19,390	17,440	136,292.93	Yes	1721818	2010-05-04		
0	18,867	19,172	24,400	167,447.85	Yes	1677781	2010-04-05		
9	18,505	18,867	28,960	197,184.46	Yes	1632371	2010-03-08		
9	18,335	18,505	13,600	92,667.84	Yes	1592719	2010-01-29		

Annalyn D. Singson

APPENDIX 2

Cost replacement of damage 100kVA transformer

SAMAR II ELECTRIC COOPERATIVE, INC.
Paranas, Samar

February 22, 20
SOA # 2016 - 000

STATEMENT OF ACCOUNT

Replacement of Busted Transformer
SAMAR STATE UNIVERSITY - MAIN CAMPUS
Catbalogan City, Samar

1 unit 100 KvA Transformer	Php	245,625.00
Installation Fee		15,000.00
3 sets cut-out assembly		17,625.00
	Php	278,250.00

Prepared by:

RHEA LOURDES M. REBANO
CWDO - Designate

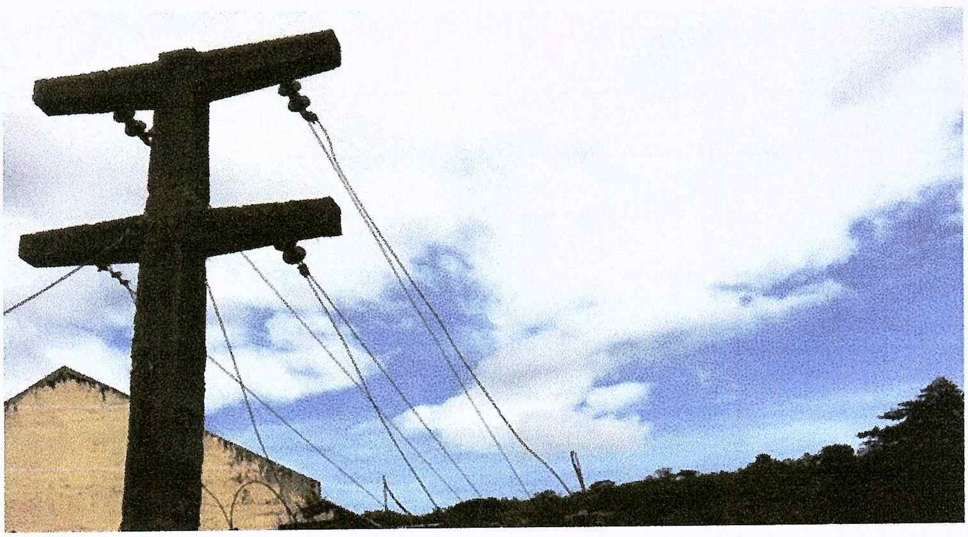
Checked :

ENGR. EDUARDO V. AROZA
MSD Chief

Approved by:

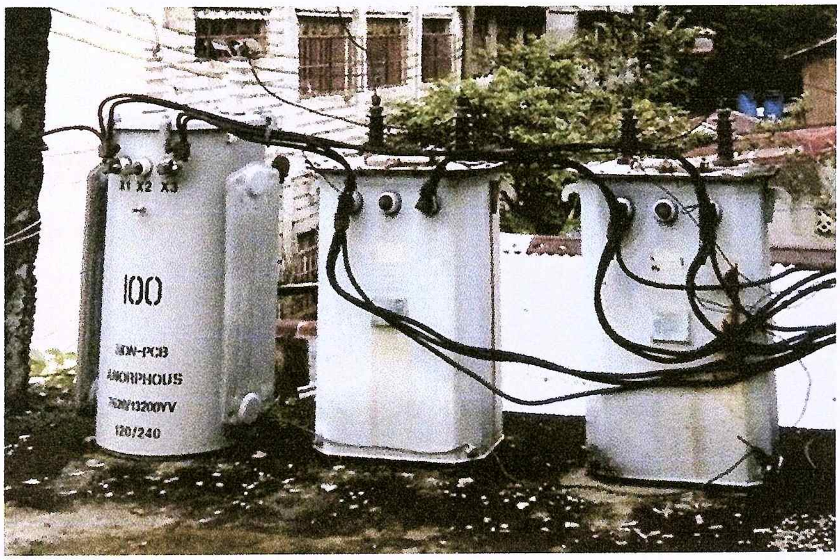
JOEY L. TALON, CPA
General Manager

APPENDIX 3



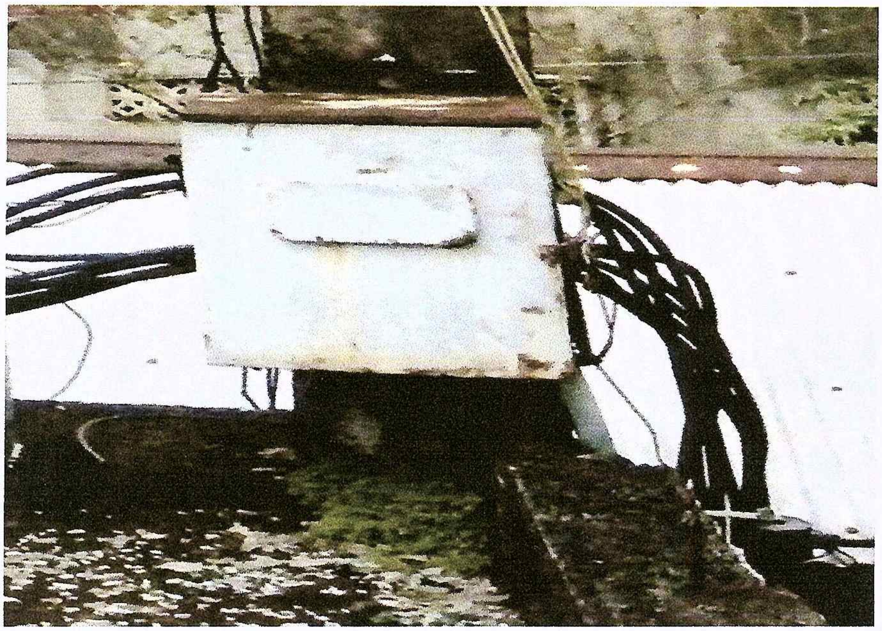
First private pole

APPENDIX 4



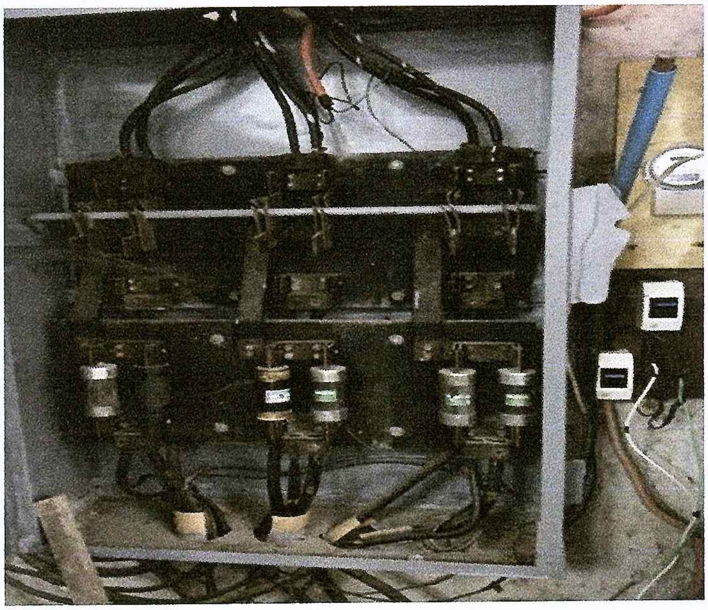
Transformer

APPENDIX 5



Service entrance conductor

APPENDIX 6

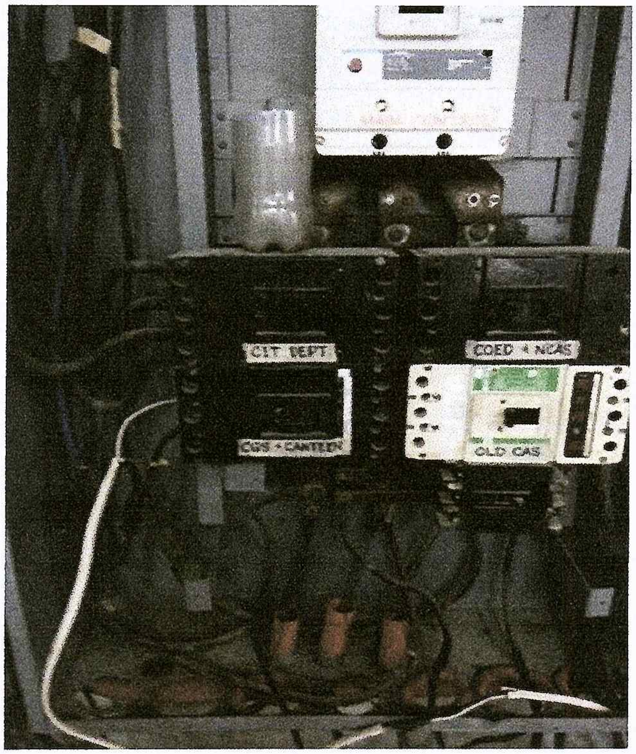


Manual Transfer Switch

APPENDIX 7

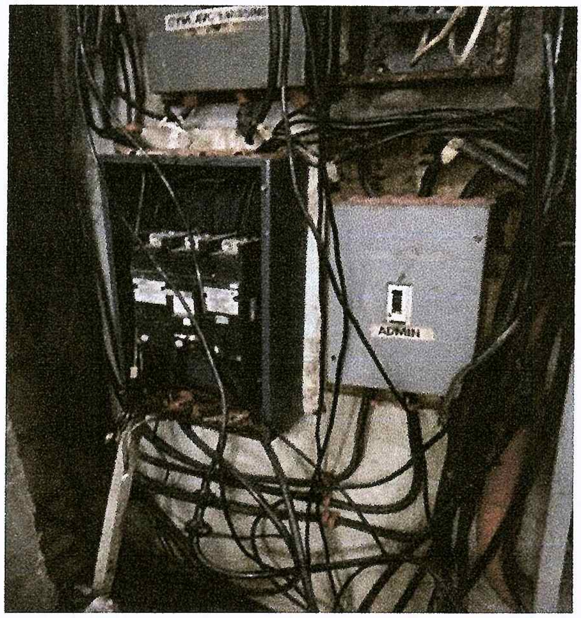
Main Service Disconnect

APPENDIX 8



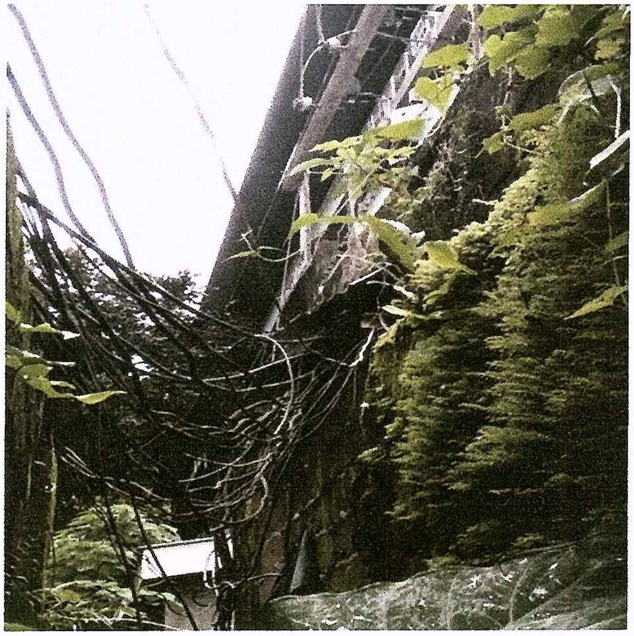
Main Distribution Panel

APPENDIX 9



Feeder circuit breaker

Appendix 10



Feeder conductors

Appendix 11

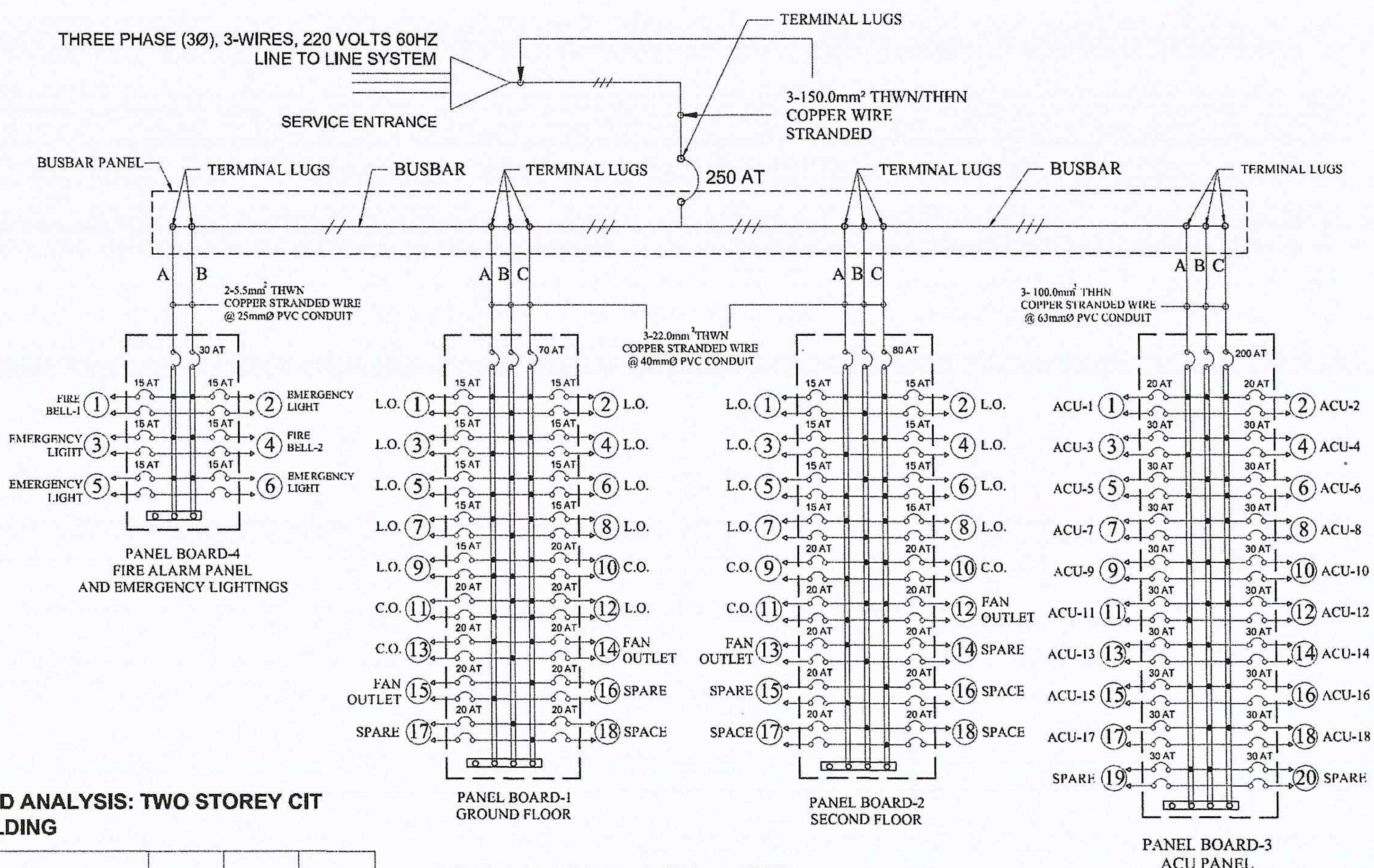
As-built plan CIT academic and convention center

ELECTRICAL SYMBOLS:

- 40-WATTS — 40-WATTS HIGHLY EFFICIENT DIFFUSED TYPE T5 / T8 FLUORESCENT LIGHT FIXTURE 1 TUBE (ELECTRONIC)
- (PL) 25-W. — 25-WATTS LED LAMP (PINLIGHT)
- (WL) 12-W. — 12-WATTS LED LAMP (WALL LAMP)
- F — FAN OUTLET (CEILING MOUNTED)
- 2 — DUPLEX CONVENIENCE OUTLET
- ACU — AIRCON OUTLET
- TEL. — TELEPHONE
- S — SINGLE POLE SWITCH, FLUSH TYPE
- S_2 — TWO POLE SWITCH, FLUSH TYPE
- S_3 — THREE POLE SWITCH, FLUSH TYPE
- S_{3W} — THREE WAY SWITCH, FLUSH TYPE
- Sa,Sb,Sc,Sd — CEILING FAN SWITCHS, FLUSH TYPE (CEILING FAN-A,B,C,D)
- SERVICE ENTRANCE, THREE PHASE 3-WIRE
- M — KILOWATT-HOUR METER
- CIRCUIT BREAKER
- MPB — CIRCUIT BREAKER MAIN PANEL BOARD
- PB-1&2 — CIRCUIT BREAKER PANEL BOARD (GRND. FLR. & 2ND FLR.)
- ACU-PB-3 — AIRCON CIRCUIT BREAKER PANEL BOARD (GRND. FLR. & 2ND FLR.)

FIRE SYMBOLS:

- EMERGENCY LIGHT — EMERGENCY LANTERN
- FIRE ALARM — FIRE ALARM
- SMOKE DETECTOR — SMOKE DETECTOR
- FIRE EXTINGUISHER — FIRE EXTINGUISHER
- PB-4 — FIRE ALARM PANEL AND EMERGENCY LIGHTINGS (GRND. FLR. & 2ND FLR.)



LOAD ANALYSIS: TWO STOREY CIT BUILDING

LOAD DESCRIPTIONS	AB	BC	CA
PANEL-1	22.747	26.304	26.872
PANEL-2	23.327	23.794	24.145
PANEL-3	137	150	137
PANEL-4	1.724		
TOTAL LOAD	184.798	200.098	188.017

A. SIZE OF SERVICE ENTRANCE CONDUCTOR:

I_{SE} =200.098 X $\sqrt{3}$ = 346.579 AMPERES
APPLYING DEMAND FACTOR OF 80%
SINCE EACH LOAD WILL NOT RUN
SIMULTANEOUSLY.

B. TOTAL CURRENT AFTER APPLYING DEMAND FACTOR:

I_{SE} = 346.579 AMPERES X 0.80 = 277.263 AMPERES

USE: 3-150.0mm THHN STRANDED COPPER WIRE
1-250 AT MAIN CIRCUIT BREAKER 3-POLE BOLT-ON
TYPE @ 90mmØ PVC CONDUIT AS RACEWAY

TOTAL LOADS OF THE BUILDING
MAIN DISTRIBUTION PANEL

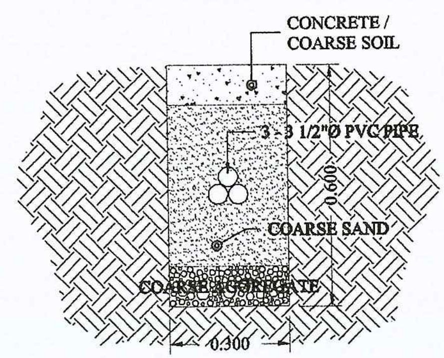
TYPE OF SERVICE: 220 VOLTS, 4-WIRE, THREE PHASE, 60HZ, LINE TO LINE

CIRCUIT NO.	DESCRIPTION	NO. OF OUTLETS	VA	VOLTS	AMPERE PER CIRCUIT			3-PHASE	CIRCUIT PROTECTION	KAIC	SIZE OF	
					AB	BC	CA				WIRE	CONDUIT
1	PB-1 A	254	1,745	220				47.87 Amp.	100 AT	14KAIC	3-30.0-mm² + 1-8.0mm² THHN Stranded Copper wire	32mm Ø RSC
2	PB-1 (ACU.)	6	22,380	220				144.31 Amp.	125 AT	14KAIC	3-50.0-mm² + 1-30.0mm² THHN Stranded Copper wire	40mm Ø RSC
3	PB-2 A	211	16,790	220				47.48 Amp.	100 AT	14KAIC	3-30.0-mm² + 1-8.0mm² THHN Stranded Copper wire	32mm Ø RSC
4	PB-2 (ACU.)	5	18,650	220				120.82 Amp.	125 AT	14KAIC	3-50.0-mm² + 1-30.0mm² THHN Stranded Copper wire	40mm Ø RSC
5	PB-3 A	206	18,340	220				39 Amp.	100 AT	14KAIC	3-30.0-mm² + 1-5.5mm² THHN Stranded Copper wire	25mm Ø RSC
6	PB-3 (ACU.)	4	14,920	220				97.334 Amp.	125 AT	14KAIC	3-50.0-mm² + 1-2.0mm² THHN Stranded Copper wire	40mm Ø RSC
7	FIRE HYDRANT	1	14,960	220				68 Amp.	150 AT	14KAIC	3-100.0-mm² + 1-14.0mm² THHN Stranded Copper wire	15mm Ø RSC
8	ELEVATOR	1	15,400	220				70 Amp.	100 AT	14KAIC	3-30.0-mm² + 1-8.0mm² THHN Stranded Copper wire	50mm Ø RSC
TOTAL			123,495					635.21 Amp.				

SIZE OF SUB-FEADER CONDUCTOR:

I_t = 635.21 x 0.80
= 508.168 Ampers

Use: 800AT, Main Circuit Breaker, 3-Phase Bolt-On, 1500AF, 50 KAIC and
3 - 150mm² + 1 - 80mm² THHN, Copper Wire Stranded
@ 65mmØ RSC Pipe



DETAIL OF ELECTRICAL
UNDER GROUND CABLING (MAIN DESTRIBUTION)
N T S

Appendix 12

As-built plan three (3) storey college of nursing building

ELECTRICAL SYMBOLS:

- (SLS) 18-W. — 18-WATTS PINLIGHT
- (SLS) 32-W. — 32-WATTS COMPACT BULB
- (P) 32-W. — 32-WATTS PINLIGHT (904-12 ALUMINUM HALOGEN SPOT LIGHT)
- (SPOT. L) 75-W. — 220V CDM-R PAR 30 (75W HALOGEN SPOT LIGHT- GPL- S196B)
- 40-WATTS — 40-WATTS HIGHLY EFFICIENT DIFFUSED TYPE T5 / T8 FLUORESCENT LIGHT FIXTURE (1 TUBE)
- C.F. — CEILLING FAN
- W.F. — WALL FAN
- — ORBIT FAN
- ACU — AIRCON OUTLET
- 2 — DUPLEX CONVENIENCE OUTLET
- S1 — ONE-GANG SWITCH, FLUSH TYPE
- S2 — TWO-GANG SWITCH, FLUSH TYPE
- S3 — THREE-GANG SWITCH, FLUSH TYPE
- S3w — THREE-WAY SWITCH, FLUSH TYPE
- — SERVICE ENTRANCE
- M — KILOWATT-HOUR METER
- — CIRCUIT BREAKER
- — CIRCUIT BREAKER PANEL BOARD
- — CIRCUIT BREAKER ACU PANEL BOARD

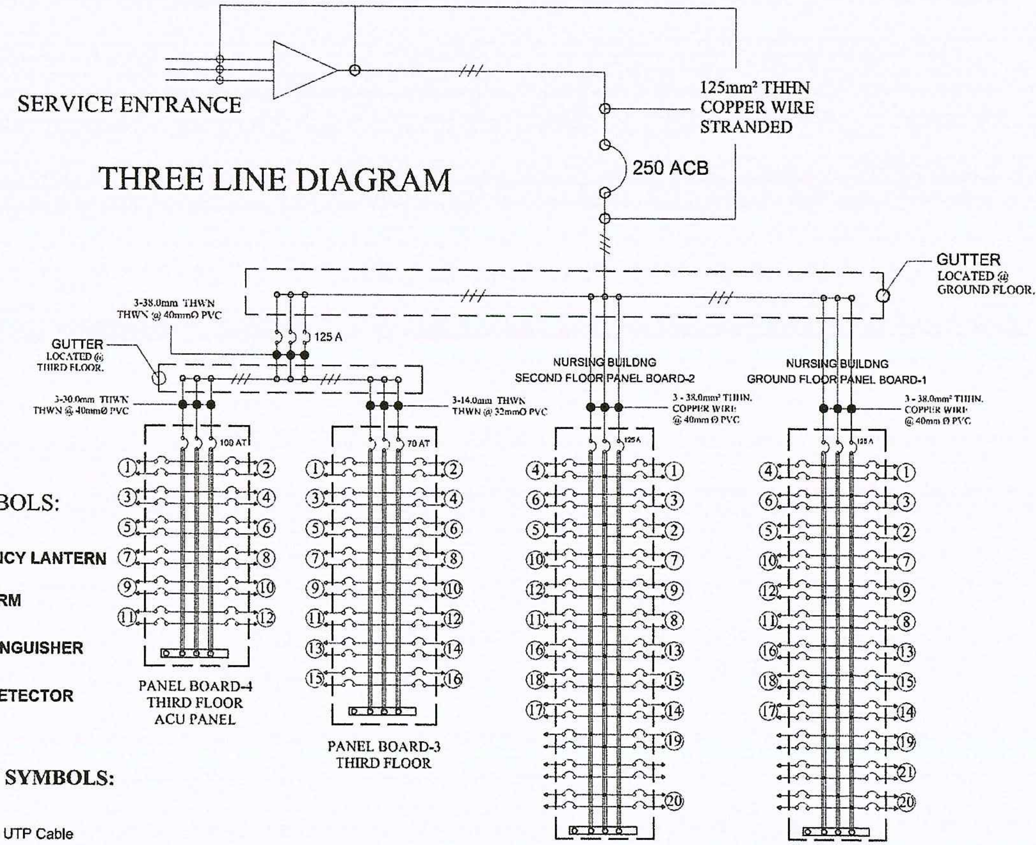
FIRE SYMBOLS:

- — EMERGENCY LANTERN
- FIRE ALARM — FIRE ALARM
- FIRE ESTINGUISHER — FIRE EXTINGUISHER
- SMOKE DETECTOR — SMOKE DETECTOR

INTERNET CONNECTION SYMBOLS:

- Cat6 — Cat6 UTP Cable
- WMPP (12P) — Wall mount patch panel (12 ports)
- CAT 6 UTP CABLE — 20mmØ PVC PIPE CONDUIT
- PVC INCOMING PIPE — 50mmØ PVC Pipe (For Cat6 Internet Wire)

THREE LINE DIAGRAM



BUILDING TOTAL LOADS:

$$I_T = \frac{30{,}720\ va}{\sqrt{3} \times 230V} \times 100\%\ D.F.$$

$$I^T = 236.06\ A$$

USE:

250 ACB, MOULDED CASE CIRCUIT BREAKER FOR MAIN DISCONNECTING MEANS
USE 65mmØ ELEC'L PIPE

Appendix 13

As-built plan three (3) storey men's dormitory building

DESIGN ANALYSIS OF MEN'S DORMITORY

CIRCUIT NO.	DESCRIPTION	AMPERE PER CIRCUIT			CKT PROTECTION	AMPERE FRAME	SIZE OF	
		AB	BC	CA			WIRE	CONDUIT
DP - 1	DISTRIBUTION PANEL BOARD - 1 (GROUND FLOOR)	56.214 73.75			150 AT	150 AF	2 - 50.0 mm2 THWN Stranded wire	1 - 50.0 mm Ø PVC PIPE
DP - 2	DISTRIBUTION PANEL BOARD - 2 (SECOND FLOOR)		56.603 99.0		175 AT	200 AF	2 - 80.0 mm2 THWN Stranded wire	1 - 63.0 mm Ø PVC PIPE
DP - 1	DISTRIBUTION PANEL BOARD - 3 (THIRD FLOOR)			56.603 87	175 AT	200 AF	2 - 80.0 mm2 THWN Stranded wire	1 - 63.0 mm Ø PVC PIPE

DISTRIBUTION PANEL BOARD - 1 (GROUND FLOOR)	DP - 1 = 56.214 + 73.75 = 129.964 Amperes
DISTRIBUTION PANEL BOARD - 2 (SECOND FLOOR)	DP - 2 = 56.603 + 99.0 = 155.603 Amperes
DISTRIBUTION PANEL BOARD - 3 (THIRD FLOOR)	DP - 3 = 51.101 + 87.0 = 138.101 Amperes

CIRCUIT NO.	DESCRIPTION	AMPERE PER CIRCUIT			CKT PROTECTION	AMPERE FRAME	SIZE OF	
		AB	BC	CA			WIRE	CONDUIT
1	PANEL BOARD - 1	56.214			60 AT	100 AF	2 - 14.0 mm2 THWN Stranded wire	32mm Ø PVC PIPE
2	ACU PB - 1	73.75			100 AT	100 AF	2 - 30.0 mm2 THWN Stranded wire	40mm Ø PVC PIPE
3	PANEL BOARD - 2		56.603		60 AT	60 AF	2 - 14.0 mm2 THWN Stranded wire	32mm Ø PVC PIPE
4	ACU PB - 2		99.0		125 AT	125 AF	2 - 38.0 mm2 THWN Stranded wire	40mm Ø PVC PIPE
5	PANEL BOARD - 3			51.101	60 AT	60 AF	2 - 14.0 mm2 THWN Stranded wire	32mm Ø PVC PIPE
6	ACU PB - 3			87	125 AT	125 AF	2 - 38.0 mm2 THWN Stranded wire	40mm Ø PVC PIPE
TOTAL		129.964	155.603	138.101	225 AT	200 AF		

ELECTRICAL SYMBOLS:

- 40-WATTS — 40-WATTS HIGHLY EFFICIENT DIFFUSED TYPE T5 / T8 FLUORESCENT LIGHT FIXTURE
- (PL) — LED LAMP (PINLIGHT)
- F — FAN OUTLET (CEILING MOUNTED)
- 2 — DUPLEX CONVENIENCE OUTLET
- ACU — AIRCON OUTLET
- TEL. — TELEPHONE
- S — SINGLE POLE SWITCH, FLUSH TYPE
- S_2 — TWO POLE SWITCH, FLUSH TYPE
- S_3 — THREE POLE SWITCH, FLUSH TYPE
- S_{3W} — THREE WAY SWITCH, FLUSH TYPE
- — SERVICE ENTRANCE, THREE PHASE 3-WIRE
- — CIRCUIT BREAKER
- — CIRCUIT BREAKER PANEL BOARD
- ACU-PB — AIRCON CIRCUIT BREAKER PANEL BOARD

$I_T = \sqrt{3} \times 155.603 = 269.512$ Amperes

Applying demand factors of 70%

$I_T = 269.512 \times 0.70 = 188.658$ Amperes

USE: 3- 100.0 mm^2 THWN/THHN Stranded copper wire
@ 3 - 63mmØ PVC conduit
1 - 225 AT 3 Pole, 3 Phase main circuit
200 Ampere Frame

INFRASTRUCTURE DEVELOPMENT SERVICE
SAMAR STATE UNIVERSITY
Catbalogan City

Project title: CONSTRUCTION OF MEN'S DORMITORY PHASE - 6 (SSU MAIN CAMPUS)

Sheet Contents:
- DESIGN ANALYSIS

Date: 1-05-16

Sheet No. 47 / E-19

Drawn by: MICHAEL ADRIAN Y. ABALOS, Draftsman / Cadd Operator, SSU Paranas Campus

Prepared by: JONAS V. VISTA, Electrical Design - Member, SSU Main Campus

Checked by: APRILLE ELLEN E. QUEBADA, Director, Infrastructure Development Services

Verified as to the Design & Quantity: FELISA E. GOMBA, PH. D., VP for Plan'ng, Res. & Ext. Serv.

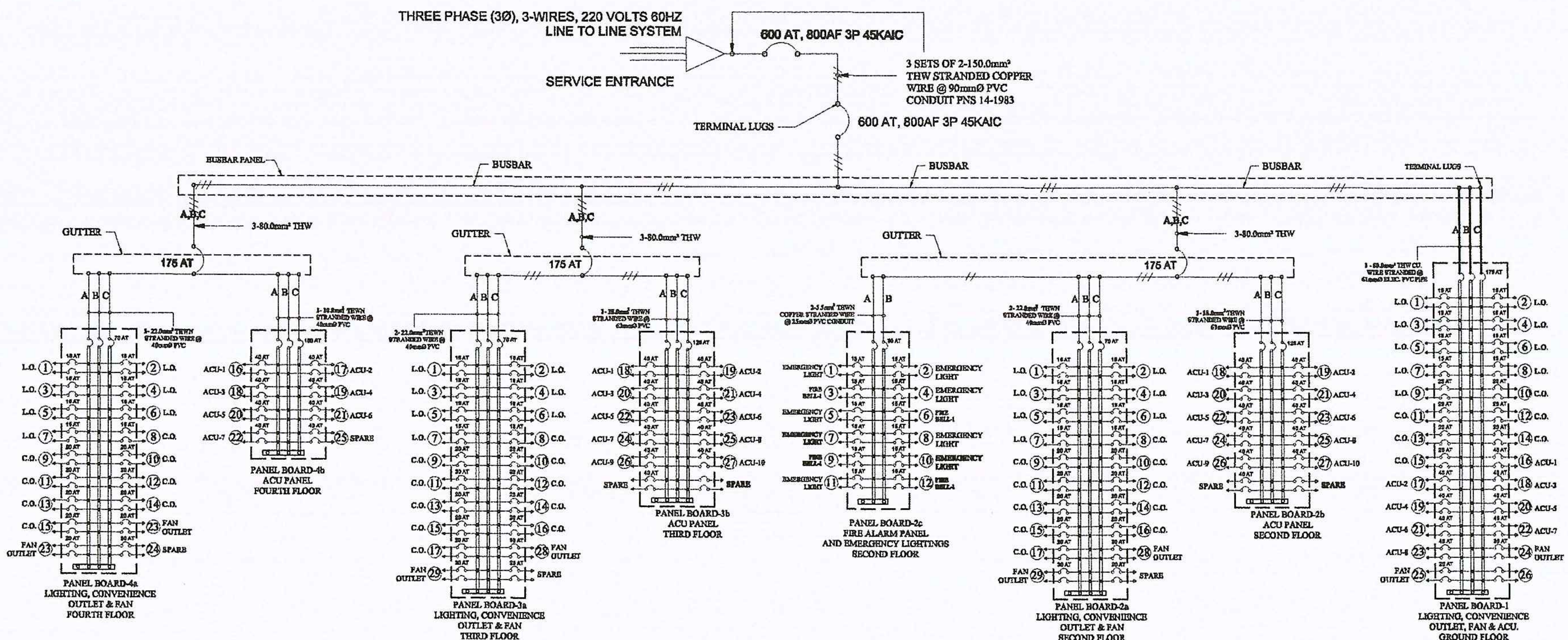
Approved: EUSEBIO T. PACOLOR, PH. D., University President

Date:

Revision No.

Appendix 14

As-built plan four (4) storey science & technology and research center



SINGLE LINE DIAGRAM

N T S

TOTAL LOADS OF THE BLDG.

TYPE OF SERVICE: 220 V, 3-WIRE, THREE PHASE, 60HZ, LINE TO LINE

AMPERE PER CIRCUIT		
AB	BC	CA
91.9304	90.654	102.4926
44.096	30.861	43.965
49.5	49.5	66
44.096	30.861	43.965
49.5	49.5	66
25.511	42.316	42.429
33	33	49.5
337.453	326.682	413.7528

TOTAL LOADS OF THE BLDG. IN AMPERES:

I_T = 413.7528 x $\sqrt{3}$ = 716.640 AMPERS

APPLYING DEMAND FACTOR OF 80%

I_T = 716.640 x 0.8 = 573.312 AMPERES

USE:

3 - SETS OF 2-150.0mm² THW STRANDED COPPER WIRE
1 - 600AT, MAIN CIRCUIT BREAKER, 3-POLE, 3-PHASE BOLT-ON, 800 AF, 45 KAIC

GENERAL NOTES:

1. ALL WORKS HEREUNDER SHALL COMPLY WITH THE PROVISIONS OF THE LATEST EDITIONS OF THE PHILIPPINE ELECTRICAL CODE PART 1. THE RULES AND REGULATIONS OF THE NATIONAL AND LOCAL AUTHORITIES CONCERNED AND THE REQUIREMENTS OF THE LOCAL POWER AND TELEPHONE COMPANY.

2. SERVICE TO THE BUILDING SHALL BE TWO WIRES SINGLE PHASE 220 VOLTS.

3. MINIMUM SIZE OF BRANCH CIRCUIT WIRE SHALL BE 2.0mm² FOR LIGHTING OUTLET AND 3.5mm² FOR CONVENIENCE OUTLET.

4. MINIMUM SIZE OF CONDUIT SHALL BE 20mm. NOMINAL DIAMETER. CONDUIT SHALL BE IN PVC, STEEL FOR SERVICE ENTRANCE, AND PVC FOR FEEDERS AND BRANCH CIRCUIT UNLESS OTHERWISE INDICATED.

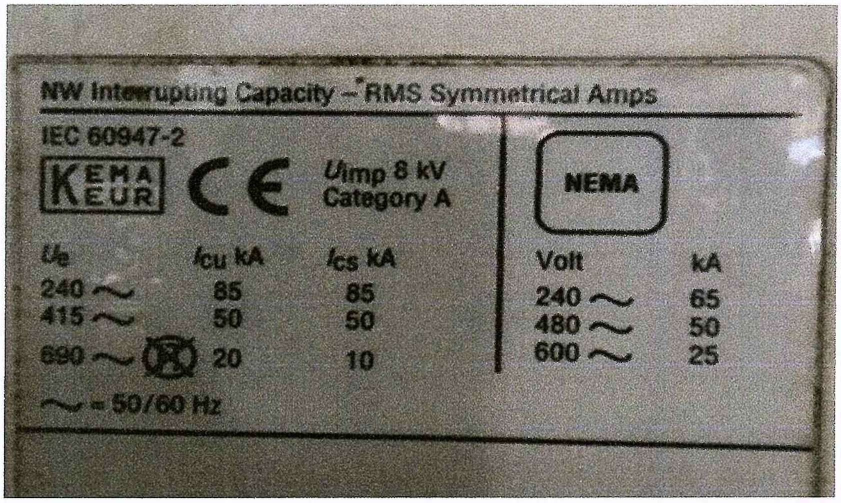
5. ALL MATERIALS TO BE USED SHALL BE NEW AND OF THE APPROVED TYPE.

6. LIGHT SWITCHES AND DUPLEX CONVENIENCE OUTLETS SHALL BE APPROVED TYPE ON ITS EQUIVALENT OR AS REQUESTED BY THE OWNER.

7. MOUNTING HEIGHT SHALL BE:
   A. LIGHT SWITCHES HEIGHTS- 1.37m ABOVE FFL.
   B. RECEPTACLES- 0.30 m. ABOVE FFL. 0.15 m. ABOVE WORKING COUNTER.

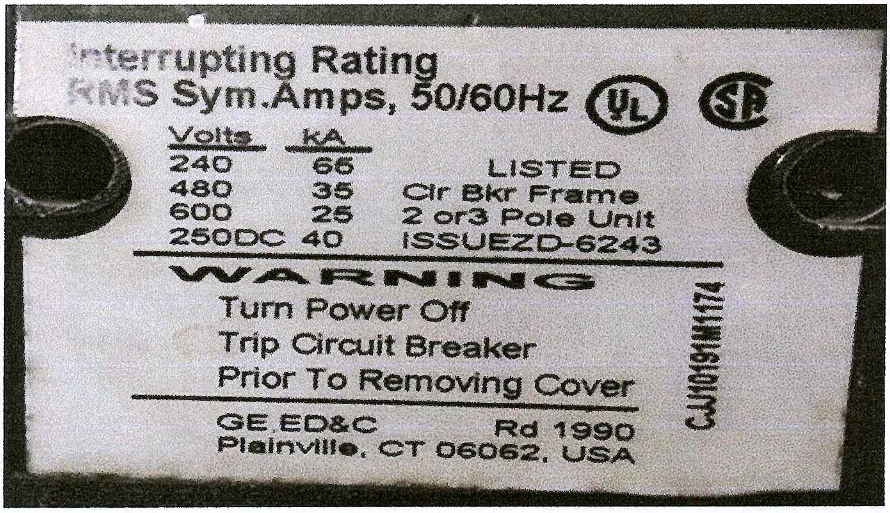
8. ALL ELECTRICAL WORKS SHALL BE DONE UNDER THE DIRECT SUPERVISION OF REGISTERED ELECTRICAL ENGINEER.

Appendix 15



KA rating of existing main service disconnect

Appendix 16



KA rating of existing feeder circuit breaker for administration building

Appendix 17

Design analysis for new SSU electrical power system

Voltage drop calculation per building:

Administration building

Voltage Drop (VD) $= I \sqrt{(R2 + X2)}$

$= 319.607\sqrt{(0.04082 + 0.03312)}$

$= 319.607\sqrt{(0.00166 + 0.00109)}$

$= 319.607\sqrt{0.00275}$

= 16.817 volts

Voltage at panel = Voltage supply – Voltage drop

= 230 - 16.760

= 213.24 volts

Percent Voltage Drop = VD x 100 / Voltage Supply

= 16.817 x 100 / 230

= 7.311 percent

Appendix 18

Design analysis for new SSU electrical power system

Short circuit calculation common bus to building:

Sizing the KA rating of administration Building is shown below.

Base voltage: 230 volts **Base power**: 1,200 VA

Base Impedance: 0.032p.u **Base Current**: 3,000 Amperes

Per unit Impedance (pu Z)

pu Z = ohms impedance/(kV)2 x Base kVA/1000

I = pu voltage / pu Z x base kVAx1000/1.732 x base voltage

FAULT at point A:

Zt = 0.032 + 0.083 = 0.115

Za= 0.115(1.191)/0.115 + 1.191

Za = 0.1048 p.u

I = pu voltage / pu Z x base kVAx1000/1.732 x base voltage

= 1/0.1048 x (1200 x1000/1.732x230)

= 28,743.803 amperes

FAULT at point B:

Zt= 0.032 + 0.083 + 0.1048 = 0.2198

Zb = 0.2198 (1.603)/ 0.2198 + 1.603)

Zb = 0.19329 p.u

I = pu voltage / pu Z x base kVAx1000/1.732 x base voltage

= 1/0.19329 x (1200x1000/1.732x230)

= 15,584.617 amperes

Appendix 19

Power per building in kilo-watts

Power per building in terms of kilowatt (kW):

Administration building

A. General lighting loads	Load
Fluorescent lightings T12 Fluorescent lightings T8 Compact fluorescent lightings	40 x 126 + 20 x 108 = 7,200 watts 36 x 75 + 18 x 108 = 9,144 watts 9 x 8 + 23 x 15 = 417 watts **Sub-total 1: = 16,761 watts**

B. General purposes outlets loads	Load
167 outlets @ 180 watts	167 x 180 = 30,060 watt First 10,000 kW (100%) = 10,000 watt Remaining at (50%) = 8,024 watt **Sub-total 2: = 20,030 watts**

C. General appliance loads:	Load
Electric fan Water dispenser TV set Photo copier machine Riso machine Computer set	23 x 75 = 17,250 watts 10 x 650 = 6,500 watts 1 x 105 = 105 watts 7 x 120 = 840 watts 1 x 500 = 500 watts 50 x 100 = 5,000 watts Total: = 30, 195 watts First 10,000 watts (100%) = 10,000 watts Remaining at (40%) = 8, 078 watts **Sub-total 3: = 18, 078 watts**
D. General Motorized load:	Load
ACU split type 2Hp, ACU window type	25 x 230 x 3 = 17,250 watts 10 x 6502760 x 20 = 55,200 watts **Sub-total 4: = 72,450 watts**

Total power = 16,761 +20,030 + 18, 078 +72,450 = 127,319 watts

= 127.319 k W

College of education

A. General lighting loads	Load
Fluorescent lightings T12 Fluorescent lightings T8 Compact fluorescent lightings	40 x 151 + 20 x 10 = 6,240 watts 36 x 120 + 18 x 15 = 4,590 watts 9 x 10 + 18 x 31 = 1,008 watts **Sub-total 1: = 11,838 watts**

B. General purposes outlets loads	Load
196 outlets @ 180 watts	196 x 180 = 35,280 watts First 10,000 kW(100%) = 10,000 watts Remaining at (50%) = 12,640 watts **Sub-total 2: = 22,640 watts**

C. General appliance loads:	Load
Electric fan Water dispenser TV set Photo copier machine LCD projectors Computer set	72x 75 = 5,400 watts 1 x 650 = 650 watts 3 x 105 = 315 watts 1 x 120 = 120 watts 4 x 50 = 200 watts 47 x 100 = 4,700 watts Total: = 11, 385 watts First 10,000 watts (100%) = 10,000 watts Remaining at (40%) = 1,385 watts **Sub-total 3: = 10,554 watts**

D. General Motorized load:	Load
1.5Hp, ACU window type	2760 x 8 = 22,080 watts **Sub-total 4: = 22,080 watts**

Total power = 11,838 +22,640+ 10,554+22,080 = 67,112 watts

= 67.112 kW

College of industrial technology

A. General lighting loads	Load
Fluorescent lightings T12 Fluorescent lightings T8 Compact fluorescent lightings	40 x 210 + 20 x 12 = 8,432 watts 36 x 72 + 18 x 4 = 2,664 watts 9 x 20 + 18 x 5 = 270 watts **Sub-total 1: = 11,366 watts**

B. General purposes outlets loads	Load
196 outlets @ 180 watts	87 x 180 = 15,660 watts First 10,000 kW (100%) = 10,000 watts Remaining at (50%) = 2,830 watts **Sub-total 2: = 12,830 watts**

C. General appliance loads:	Load
Electric fan Water dispenser Computer set Electric grinder	46 x 75 = 3,450 watts 3 x 650 = 1,950 watts 14 x 100 = 1,400 watts 1 x 746 = 746 watts **Sub-total 3: = 7,546 watts**

D. General Motorized load:	Load
Air-conditioning Unit Welding machine Refrigerator (Roll-in pass through) Sewing machine	4 x 12 x 230 = 11,040 watts 1 x 3000 + 1 x 5000 = 8,000 watts 2 x 1,500 = 3,000 watts 11 x 373 = 4,103 watts **Sub-total 4: = 26,143 watts**

Total power = 11,366+12,830+ 7,546+26,143 = 57,885 watts

= 57.885 kW

Two (2) storey electrical & mechanical technology

A. General lighting loads	Load	
Fluorescent lightings T12	40 x 75 + 20 x 12	= 3,240 watts
Fluorescent lightings T8	36 x 15+ 18 x 2	= 576 watts
Compact fluorescent lightings	9 x 12 + 18 x 2	= 270 watts
	Sub-total 1:	**= 4,230 watts**

B. General purposes outlets loads	Load	
43 outlets @ 180 watts	43 x 180	= 7,740 watts
	Sub-total 2:	**= 7,740 watts**

C. General appliance loads:	Load	
Electric fan	20x 75	= 1,500 watts
Water dispenser	3 x 650	= 1,950 watts
Computer set	6 x 100	= 600 watts
Electric grinder	4 x 746	= 2,984 watts
	Sub-total 3:	**= 7,034 watts**

D. General Motorized load:	Load	
Air-conditioning unit	1 x 4 x 230	= 920 watts
	Sub-total 4:	**= 920 watts**

E. Industrial machineries	Load	
Welding machine	2 x 3,000	= 6,000 watts
Lathe Machine	2 x 2,238	= 4476 watts
Milling machine	2 x 1,119	= 2238 watts
Electric furnace	1 x 12,000	= 12,000 watts
Cutter press machine	**Sub-total 5:**	**= 27,698 watts**

Total power = 4,230 +7,740 + 7,034 +920 +27,698 = 47,622 watts

= 47.622 kW

Two (2) storey college of graduate studies

A. General lighting loads	Load	
	Sub-total 1:	**= 3,788 watts**
B. General purposes outlets loads:	**Sub-total 2:**	**= 5,500 watts**
C. General appliance loads:	Load	
Photo copier machine	2 x 120	= 240 watts
Electric fan	9 x 75	= 675 watts
Water dispenser	3 x 650	= 1,950 watts
Computer set	8 x 100	= 800 watts
TV set	2 x 105	= 210 watts
	Sub-total 3:	**= 3,875 watts**
D. General Motorized load:	Load	
Air-conditioning unit	14 x 8 x 230	= 25,760 watts
	Sub-total 4:	**= 25,760 watts**

Total power = 3,788 +5,500 + 3,875 +25,760 = 38,923 watts

= 38.923 kW

Single storey, old college of arts and sciences building

A. General lighting loads	Load	
	Sub-total 1:	**= 7,045 watts**
B. General purposes outlets loads:	**Sub-total 2:**	**= 3,500 watts**
C. General appliance loads:	Load	
Electric fan	30 x 75	= 2250 watts
Water dispenser	2 x 650	= 1,300 watts
Computer set	3 x 100	= 300 watts
TV set	1 x 105	= 105 watts
	Sub-total 3:	**= 3,955 watts**
D. General Motorized load:	Load	
Air-conditioning unit	6 x 12 x 230	= 16,560 watts
	Sub-total 4:	**= 16,560 watts**

Total power = 7,045+3,500 + 3,955 +16,560 = 31,060 watts

= 31.060 kW

New college of arts & sciences (CAS) building-1

A. General lighting loads	Load
Fluorescent lightings T12 Fluorescent lightings T8 Compact fluorescent lightings	40 x 210 + 20 x 12 = 8,432 watts 36 x 72 + 18 x 4 = 2,664 watts 9 x 20 + 18 x 5 = 270 watts **Sub-total 1: = 11,366 watts**

B. General purposes outlets loads	Load
135 outlets @ 180 watts	135 x 180 = 24,300 watts First 10,000 kW (100%) = 10,000 watts Remaining at (50%) = 7,150 watts **Sub-total 2: = 17,150 watts**

C. General appliance loads:	Load
Electric fan Computer set TV set LCD projector	15 x 75 = 1,125 watts 44 x 100 = 4,400 watts 14 x 100 = 1,400 watts 1 x 50 = 50 watts **Sub-total 3: = 5,680 watts**

D. General Motorized load:	Load
Air-conditioning unit	(1 x 8 x 230) + (3 x 16 x 230) = 12,880 watts **Sub-total 4: = 12,880 watts**

Total power = 11,366 +17,150 + 5,680 +12,880 = 47,076 watts

= 47.076 kW

College of engineering

A. General lighting loads	Load
Fluorescent lightings T12 Fluorescent lightings T8 Compact fluorescent lightings	40 x 219 + 20 x 18 = 9,120 watts 36 x 28 + 18 x 12 = 1224 watts 9 x 14+ 18 x 10 = 306 watts **Sub-total 1: = 10,650 watts**

B. General purposes outlets loads	Load
228 outlets @ 180 watts	228 x 180 = 41,040 watts First 10,000 kW (100%) = 10,000 watts Remaining at (50%) = 15,520 watts **Sub-total 2: = 25,520 watts**

C. General appliance loads:	Load
Electric fan Computer set	78 x 75 = 5,850 watts 20 x 100 = 2,000 watts **Sub-total 3: = 7,850 watts**

D. General Motorized load:	Load
Air-conditioning unit	(1 x 12 x 230) + (4 x 16 x 230) = 17,480 watts **Sub-total 4: = 17,480 watts**

Total power = 10,650 +25,520 + 7,850 +17,480 = 61,500 watts

= 61.500 kW

Two (2) storey hub (The Internet Cafe)

A. General lighting loads	Load	
	Sub-total 1:	**= 1,332 watts**
B. General purposes outlets loads:	**Sub-total 2:**	**= 2,800 watts**
C. General appliance loads:	Load	
Electric fan	2 x 75	= 150 watts
Computer set	65 x 100	= 6,500 watts
	Sub-total 3:	**= 6,650 watts**
D. General Motorized load:	Load	
Air-conditioning unit	3 x 16 x 230	= 11,040 watts
	1 x 8 x 230	= 1,840 watts
	Sub-total 4:	**= 12,880 watts**

Total power = 1,332+2,800 + 6,650+12,880 = 23,662 watts

= 23.662 kW

CURRICULUM VITAE

CURRICULUM VITAE

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ADDRESS	:	P1 Brgy 027 Canlapwas Catbalogan City, Samar
PLACE OF BIRTH	:	Silanga Catbalogan City, Samar
DATE OF BIRTH	:	June 16, 1979
PRESENT POSITION	:	Instructor 1
NAME OF AGENCY	:	Samar State University, Main Campus

EDUCATIONAL BACKGROUND

Elementary .... Silanga Elementary School
1986 - 1992

Secondary .... Samar State University (Formerly Samar State Polytechnic College)
1992 – 1996

College .... Samar State University (Formerly Samar State Polytechnic College)
1996 – 2001

Graduate .... Samar State University
2014 – Present

Curriculum pursued .... Master in Technician Education (MTE)

Major .... Electrical Technology

CIVIL SERVICE ELIGIBILITY

Registered Electrical Engineer .... Re No: 0028796

Registered Master Electrician .... Re No: 002449

WORK EXPERIENCE

11/15/2016	TO DATE	INSTRUCTOR 1	SAMAR STATE UNIVERSITY
11/15/2013	12/31/2016	INSTRUCTOR 1	SAMAR STATE UNIVERSITY
11/15/2010	12/31/2015	INSTRUCTOR 1	SAMAR STATE UNIVERSITY
5/13/2009	1/20/2010	REEFER TECHNICIAN	HOLLAND AMERICA CRUISE LINES
		MS OOSTERDAM	UNITED PHILIPPINE LINES STA. CLARA ST
		(PASSENGER VESSEL-82,305 GT-WORLD WIDE)	FORT SANTIAGO INTRAMUROS, MANILA
3/15/2008	1/30/2009	REEFER TECHNICIAN	HOLLAND AMERICA CRUISE LINES
		MS MAASDAM	UNITED PHILIPPINE LINES STA. CLARA ST
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11/26/2006	11/5/2007	REEFER TECHNICIAN	HOLLAND AMERICA CRUISE LINES
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TRAININGS AND SEMINARS

Energy Consultancy Audit Training and Accreditation Program

EVCIERD, EVSU Tacloban City Leyte

November 26 to 28, 2017

Applied Short Circuit Analysis in Commercial and Industrial Power System

Institute of Integrated Electrical Engineers of the Philippines IIEE, Monte de Piedad Street Cubao Quezon City,

March 18, 2015 to March 19, 2015

Engineering and Technology Educational Training Program (Electro pneumatics and Mechatronics)

Eulogio Amang Rodriguez Institute of Technology

May 26, 2014 to May 30, 2014

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