

RESEARCH ARTICLE

Design and Technical Consideration of Underground Power Feeder in CBSUA Sipocot Campus

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ABSTRACT

Transitioning to a world-class university and establishing a smart campus requires a comprehensive approach to infrastructure, particularly power distribution. As Central Bicol State University (CBSUA) aims to become a beacon of educational excellence while embracing resilience and sustainability, designing an underground power feeder system becomes crucial. This research explores the requirements and challenges of upgrading the distribution line to meet increasing load demands driven by academic and technological advancements. By analyzing existing infrastructure, projected load increases, and technological advancements, this study formulates a strategic blueprint for an underground power feeder network. It integrates principles from electrical engineering, urban planning, and sustainability to design a system that addresses current demands and anticipates future growth, aligning with CBSUA's vision of resilience and sustainability. The research highlights the transformative potential of a robust underground power feeder system in supporting a modern educational institution's needs. The proposed system enhances reliability, minimizes downtime, and optimizes energy distribution, fostering a dynamic and conducive learning environment. It also emphasizes sustainability, advocating for integrating renewable energy sources, energy-efficient technologies, and eco-friendly materials. By mitigating environmental impact and reducing carbon footprint, CBSUA aims to set a precedent for sustainable campus development globally. This research supports CBSUA's vision for a world-class university and smart campus by offering a framework for the design and technical considerations of an underground power feeder system. Prioritizing resilience, sustainability, and adaptability, the proposed system advances academic excellence and promotes environmental stewardship in educational innovation.

KEYWORDS:

Underground Power Feeder Design, Technical Considerations, Power Feeder

1 | INTRODUCTION

The transition from traditional exposed wire systems to underground power feeders presents a pivotal opportunity for enhancing the power distribution system at CBSUA. Sipocot Campus. This study investigates the design and technical considerations of implementing an underground power feeder on the campus. It aims to uncover its inherent benefits over exposed cable systems while addressing key objectives [1] [2]. Firstly, the study scrutinizes the decision-making process between underground and

exposed distribution cabling systems, assessing reliability, maintenance, aesthetics, and environmental impact. By comparing these systems, it seeks to identify the superior choice regarding safety, dependability, and visual impact, particularly pertinent for educational institutions aiming to provide secure and visually appealing learning environments [3] [2].

Secondly, the research delves into the design considerations specific to underground cabling systems, focusing on cable routing, burial depth, insulation, grounding, and protection against external factors. This exploration aims to ensure optimal performance and lifespan of the electrical infrastructure, which is crucial for sustaining a reliable power distribution system on campus. Additionally, the study evaluates the cost implications associated with undergrounding the distribution system, providing insights into this transformation's economic viability and potential long-term savings or operational efficiency. By understanding the financial aspect, stakeholders can make informed decisions regarding infrastructure investments for improved sustainability and functionality [4] [5].

The significance of this research extends to various stakeholders, including students, educators, and engineering professionals. The project offers educational value for students by providing insight into real-world engineering principles applications, enhancing their understanding of electrical infrastructure design. Educators can utilize the findings to enrich teaching materials and facilitate practical learning experiences related to power distribution systems [2].

Furthermore, professionals in the field of engineering stand to benefit from empirical insights into the design and technical aspects of underground power feeders, which aid in their professional development and guide future projects in similar contexts. Moreover, the study contributes to engineering knowledge by adding empirical insights into underground power feeders' benefits, design concerns, and economic implications, informing best practices in electrical distribution network design and implementation [6]; [7].

2 | METHODOLOGY

The proposed research delves into the design considerations and financial investment associated with underground cabling systems, specifically focusing on implementing an underground power feeder at Central Bicol State University (CBSUA). By employing a mixed-methods approach encompassing qualitative and quantitative methodologies, including literature review, case studies, interviews, and surveys, the study aims to thoroughly analyze the benefits, design parameters, and cost implications of underground power feeders [8] [9]. To gather comprehensive data, various research instruments were utilized, including multiple criteria decision analysis (MCDA), survey questionnaires, and structured interviews, which enable a deeper understanding of the subjective experiences, perceptions, and perspectives of stakeholders involved in underground power feeder implementation [4] [5].

For instance, interviews with university administrators, electrical engineers, and maintenance personnel provided valuable insights into the practical aspects of underground cabling systems, including challenges, best practices, document analysis, and cost estimation. These instruments are designed to collect specific data and insights relevant to the research objectives, facilitating a thorough examination of the benefits of underground cabling systems, electrical system design considerations, and the financial viability of implementing underground power feeders.

Data analysis was conducted meticulously, employing both quantitative and qualitative techniques. Quantitative analysis of survey responses involved descriptive statistics and correlation analysis in uncovering patterns and relationships among variables related to underground power feeder design and implementation; this involves tallying responses to determine the ranking, mean, and percentages of each criterion, providing an overview of participant preferences. Qualitative analysis of structured interviews entails thematic analysis of interview transcripts, focusing on identifying significant themes regarding cable routing, burial depth, cable types, protective measures, and design optimizations [10] [11].

Furthermore, a cost estimation worksheet was utilized to analyze the financial implications of undergrounding the distribution system, encompassing various cost components associated with implementing underground power feeders. This comprehensive analysis aims to provide informed recommendations for designing and implementing underground power feeder systems at CBSUA, ultimately contributing to safer, more sustainable, and visually appealing campus infrastructure [6] [7].

After applying the formula for each factor, the ranking for underground and exposed systems is determined. In this case, underground and exposed systems received the same ranking of 2 for Aesthetics, indicating similar perceived importance of aesthetic considerations among the respondents. This formula facilitates a quantitative comparison of decision factors, aiding stakeholders and decision-makers in evaluating the attributes of different distribution cabling systems.

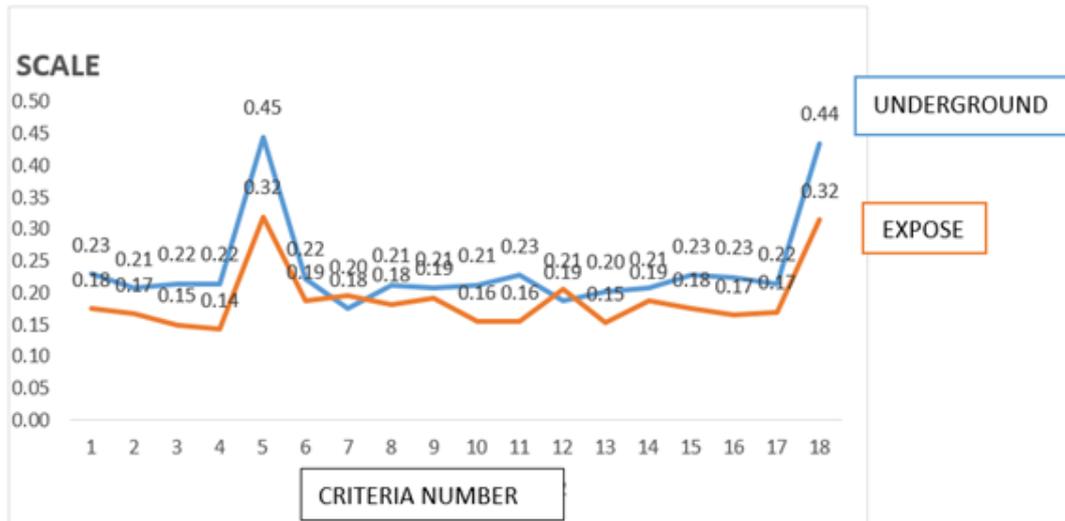


FIGURE 2 Ranking

3.2 | GRAPHICAL REPRESENTATION

The graphing method visually represented the weighted scores, clearly comparing the two cabling systems across different criteria. Analyzing the plotted results showed that underground systems consistently outperformed exposed systems in several key factors, leading to their higher overall ranking.

After utilizing the graphing method to plot the results of the weighted scores for the decision factors comparing underground and exposed distribution cabling systems, it became evident that underground ranked one while exposed ranked 2 in the overall comparison. This ranking signifies that the respondents favored underground systems over exposed systems, indicating a preference for underground cabling in various decision factors.

Design and Technical Considerations for Underground Power Feeder Distribution System

- 1. Load Analysis-** Begin by thoroughly analyzing the target area's load requirements to determine the feeder system's capacity and distribution needs.
- 2. Route Selection-** Identify the underground feeder system's optimal route, considering the terrain, existing infrastructure, accessibility, environmental impact, and future expansion needs.
- 3. Cable Selection-** Choose appropriate cables based on voltage requirements, load capacity, insulation type, environmental conditions, and expected lifespan. Consider factors like voltage drop, fault current levels, and temperature ratings.
- 4. Protection and Safety Measures-** Implement safety measures to protect the feeder system from overcurrent, short circuits, ground faults, and other electrical hazards. This includes selecting and installing protective devices such as fuses, circuit breakers, and surge arresters.
- 5. Cable Installation-** Ensure proper installation techniques are followed to minimize cable damage and ensure longevity. This includes considerations for trenching, cable laying depth, cable support, and jointing/splicing procedures.

6. **Grounding and Bonding**- Implement adequate grounding and bonding systems to ensure safety, equipment protection, and compliance with regulatory requirements. This involves proper placement of grounding electrodes and bonding conductors.
7. **Environmental Considerations**- Assess and mitigate potential environmental impacts associated with installing and operating the underground feeder system. This includes soil erosion, water table levels, vegetation management, and wildlife preservation considerations.
8. **Maintenance Access**- Design the system for easy access and maintenance of underground components, such as manholes, vaults, and access points. Consideration should be given to accessibility for inspection, testing, and repairs.
9. **Regulatory Compliance**- Ensure compliance with relevant regulatory standards, codes, and guidelines governing the design, installation, and operation of underground power distribution systems.
10. **Topography**- refers to the physical features and layout of the Earth's surface, including its elevation, contours, and natural landforms such as mountains, valleys, and plains. It provides a detailed depiction of the terrain, which is essential for various applications like mapping, urban planning, and environmental assessment.

3.3 | SINGLE LINE DIAGRAM

The single-line diagram shown in Figure 3 simplifies the electrical system layout, highlighting the key components and their specifications. The diagram analysis reveals the configuration and ratings of each component, which are crucial for understanding the overall functionality and capacity of the electrical system. The specified transformer rating of 1MVA indicates its capacity to handle a maximum apparent power of 1 megavolt-ampere. It serves as a crucial step-down component for reducing the primary voltage to a lower secondary voltage suitable for distribution within the facility.

Including power monitoring features in the low-voltage switch gear enhances the system's capability for real-time monitoring and control of electrical parameters such as voltage, current, and power factor. This enables efficient management of power distribution and ensures optimal system performance. Multiple distribution panels with adequate current and voltage ratings indicate the ability to distribute power to various loads or circuits within the facility, ensuring reliable and efficient electrical power distribution.

3.4 | DESIGN COMPONENTS AND EQUIPMENT SPECIFICATION

1. **Overhead Power Supply**- The overhead power supply is depicted as a 13.2kV wye 3-wire system with a neutral conductor. This configuration indicates a typical distribution system commonly used to supply power from the utility grid to the transformer.
2. **Transformer**- The transformer in the electrical system is specified as a 1MVA 3-phase pad-mounted transformer with a primary voltage of 13.2kV and a secondary voltage of 230V. The transformer is configured in a Y-to-delta (wye to delta) connection, a common arrangement for stepping down the voltage from the primary to the secondary distribution level.
3. **Low Voltage Switchgear**- The low voltage switchgear is specified as a 1MVA, 2500A, 230V, 3-pole switchgear. It is equipped with power monitoring features such as voltage (VL), current (IL1, IL2, IL3), power factor (PF), and digital display. This switchgear is critical for controlling and distributing electrical power within the system.
4. **Distribution Panels**- Six distribution panels are indicated in the single-line diagram, each rated at 400A and 230V with 3-pole configurations. These distribution panels are responsible for further distributing power to various loads or circuits within the facility.
5. **Capacitor banks**- can be strategically placed along the distribution lines or integrated with the Low Voltage Switch Gear to provide reactive power support. Reactive power is necessary for maintaining voltage levels within acceptable limits. When capacitors are added to the system, they can supply reactive power, which helps offset the effects of inductive loads and reduces the overall voltage drop.

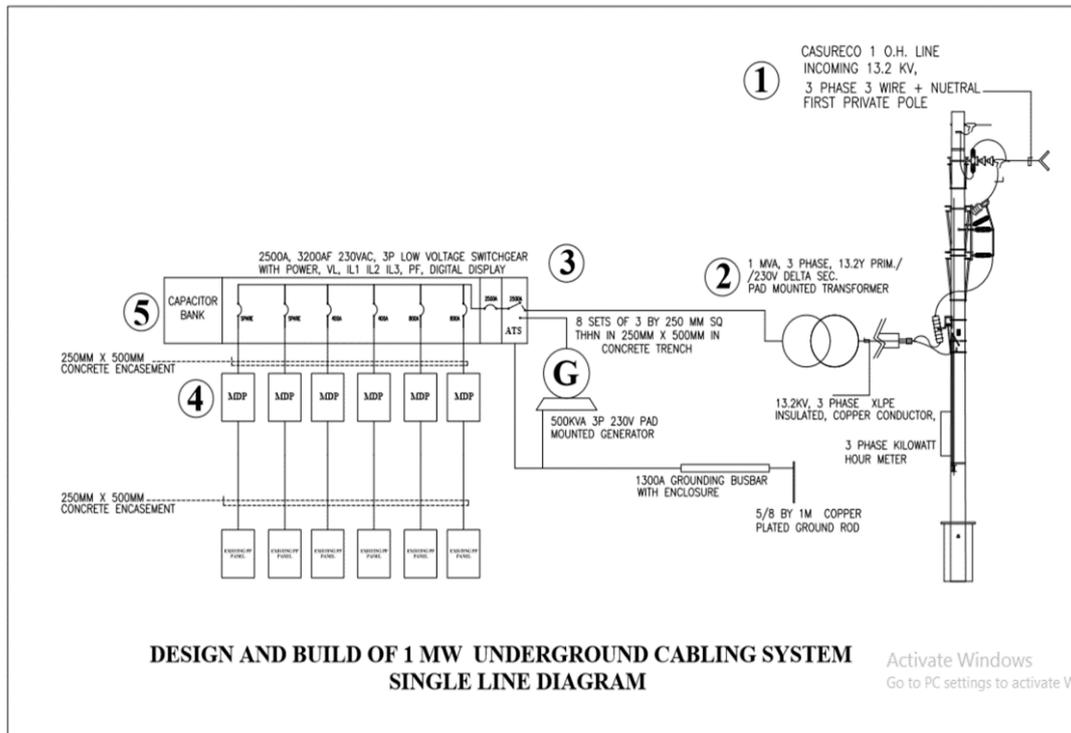


FIGURE 3 Design and Build of 1MV Underground Cabling System Single Line Diagram

Overall, the analysis of the single-line diagram provides valuable insights into the configuration and specifications of the electrical system, facilitating a better understanding of its design and technical considerations.

3.5 | UNDERGROUND FEEDER LAYOUT

The underground feeder layout shown in Figure 4 reflects the underground power feeder system's routing and critical design parameters, aligning with the Philippine Electrical Code. As mandated by the code, the burial depth of 600 mm below ground level ensures the requisite protection and safety standards for the power cables. Additionally, the strategic placement of concrete PVC spacers at intervals of 900 mm further reinforces the stability and protection of the cables, minimizing the risk of damage or interference. Moreover, the meticulous positioning of manholes within the routing layout facilitates accessibility for maintenance and troubleshooting tasks, enhancing the overall reliability and efficiency of the underground power feeder system. By meticulously adhering to these design considerations and regulatory requirements, the installation and operation of the underground power feeder system are optimized to meet safety standards while ensuring uninterrupted power supply within the premises.

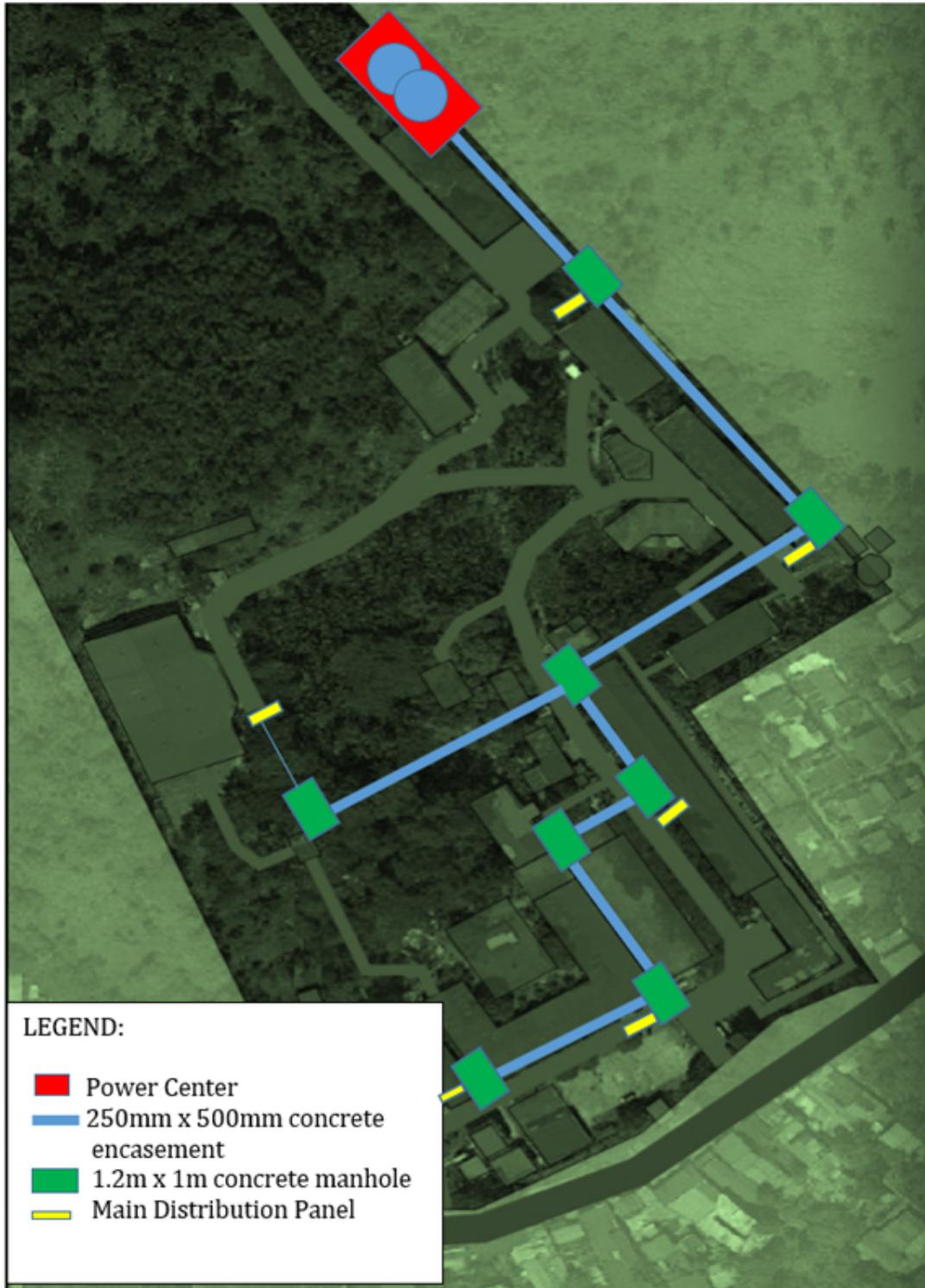


FIGURE 4 Underground Distribution Network

TABLE 1 Project Investment

Item No.	Unit of Issue	ITEM DESCRIPTION	Quantity	Unit Cost	Total Cost
I. Underground Cabling System					
A. First Private Pole					
1	ASSY	Civil And Electrical Works	1	P400, 000	P400, 000
B. Equipment					
2	ASSY	1Mva, 3Phase, 3Pole, 230V Secondary, Pad Mounted Distribution Transformer	1	P1, 100, 000	P1, 100, 000
3	ASSY	1 Mva, 2500A Main. 3200Af, 3Phase, 3Pole 230V Low Voltage Switchgear With I1, 12, I3 Pl, VI And Pf Indicator And Capacitor Bank (1 Main, 6 Branch + 4 Spare)	1	P1, 100, 000	P1, 100, 000
4	ASSY	500Kva, 230V, 3Pole, 3Phase Auto Start, Pad Mounted Generator	1	P2, 400, 000	P2, 400, 000
5	ASSY	400A Main 230V 3Pole, 6 Branch + 4 Spare, Main Distribution Panel Assembly With Breaker Inside.	6	P100, 000	P600, 000
6	ASSY	Three Phase Kwhr Meter	1	P50, 000	P50, 000
Equipment Total					P5, 250, 000
C. Main Feeder					
7	ASSY	100Mm By 300Mm By 2M Cable Trench With Plain Sheet Cover	60	P1, 500	P90, 000
8	ASSY	Perforated Cable Tray With Cover 100 Mm Height By 300Mm Width	63	P1, 500	P94, 500
9	PCS	Full Threaded Rod 3/8 Inch Dia. X 1M	100	P35	P3, 500
10	MTS	250Mm Sq Thhn Wire	900	P2, 400	P2, 160, 000
Main Feeder Total					P2, 348, 000
D. Sub Main Feeder					
11	ASSY	300Mm By 100 Mm Cable Trench With Plain Sheet Cover	63	P1, 500	P94, 500

12	ASSY	Perforated Cable Tray With Cover 100 Mm Height By 300Mm Width	1, 000	P1, 500	P1, 500, 000
13	PCS	Full Threaded Rod 3/8 Inch Dia. X 1M	932	P35	P32, 620
14	MTS	6 By 4 Inch Pvc Pipe In Concrete Encasement	350	P9, 428	P3, 299, 800
15	MTS	250Mm Sq Thhn Wire	5, 400	P2, 400	P12, 960, 000
16	SET	Civil Works Of Manhole With Round Metal Cover	12	P15, 000	P180, 000
Sub Main Feeder Total					P18, 066, 920
E. Equipment Grounding System					
17	PCS	Ground Rod 10 Feet Length Copper Plated	3	P1, 100	P3, 300
18	ROLLS	25M Pure Copper, 10Mm Bare Copper Grounding Cable	2	P4, 800	P9, 600
19	BOX	5.5Mm Sq Thhn Wire	2	P6, 800	P13, 600
Equipment Grounding System Total					P26, 500
LOT	F.	Miscellaneous	1	P186, 980	P186, 980
LOT	G.	1 Power House And 6 Ee Room	1	P2, 000, 000	P2, 000, 000
LOT	H.	Design With Sign And Sealed	1	P500, 000	P500, 000
LOT	I.	Labor	1	P5, 000, 000	P5, 000, 000
Grand Total					P33, 778, 400

A detailed breakdown of costs is associated with implementing the underground power feeder system is shown in Table 2. The cost allocation for various components is as follows:

- A. The expenditure for the first private pole amounts to 400, 000 pesos, reflecting the initial infrastructure investment required for the system's establishment.
- B. Equipment costs contribute significantly to the overall expenditure, totaling 5, 250, 000 pesos, highlighting the expenses associated with procuring essential components and machinery.
- C. The main feeder incurs costs of 2, 348, 000 pesos, representing the core infrastructure for transmitting power from the source to the distribution network.
- D. Sub-main feeder expenses amount to 18, 066, 920 pesos, indicating the substantial investment needed for extending the power distribution network to multiple locations within the premises.
- E. Equipment grounding system costs are relatively minimal at 26, 500 pesos, emphasizing the importance of ensuring electrical safety through proper grounding mechanisms.
- F. Miscellaneous expenses totaling 186, 980 pesos encompass additional costs not classified under specific categories, including administrative fees and incidental expenses.
- G. The allocation for one powerhouse and six electrical engineering (EE) rooms amounts to 2, 000, 000 pesos, reflecting the costs associated with constructing dedicated facilities for housing electrical equipment and personnel.

- H. Design costs with signing and sealing account for 500, 000 pesos, indicating the expenses incurred for professional design services to ensure compliance with regulatory standards and engineering specifications.
- I. Labor costs constitute a significant portion of the budget, totaling 5, 000, 000 pesos, highlighting the expenses associated with employing skilled labor for system installation and maintenance.

Overall, this chapter's detailed breakdown of costs underscores the comprehensive financial planning and allocation necessary for successfully implementing the underground power feeder system, ensuring efficient and reliable electrical infrastructure within the premises.

3.6 | COST AND EFFECTIVE STRATEGY

Ensuring the feasibility of the project hinges on effective cost-management strategies. Meticulous cost planning and budget allocation are crucial, with a thorough assessment of each component to enable precise financial forecasting. Strategic procurement practices, such as bulk purchasing agreements and exploring cost-effective alternatives, contribute to overall savings. Additionally, adopting energy-efficient technologies and sustainable practices aligns with environmental considerations and yields long-term cost reductions [12].

Collaboration with local authorities can uncover potential financial incentives or grants, enhancing economic viability. Partnerships with reputable contractors ensure cost-effective labor without compromising quality. Innovative financing models like public-private partnerships or crowd-funding initiatives diversify funding sources and mitigate financial risks. Continuous project monitoring and refining cost estimates are vital for staying within budgetary constraints[3]

Meticulous financial planning, strategic procurement, sustainable practices, and innovative funding models collectively ensure the cost-effectiveness and feasibility of the project, paving the way for its successful implementation.

4 | CONCLUSION

This research investigates the transition from conventional exposed wiring systems to underground power feeders within educational institutions, specifically focusing on the Central Bicol State University of Agriculture (CBSUA) campus. Through a meticulous examination of decision-making processes, design considerations, costs, and implementation strategies, several key findings have emerged, shedding light on crucial aspects of this transition.

The decision-making process regarding the choice between underground and exposed distribution cabling systems involves a multifaceted evaluation of various factors. These factors include aesthetic considerations, environmental impact, safety, reliability, and regulatory compliance. This study has revealed respondents' distinct preference for underground systems, highlighting their superior performance across different criteria. This preference is rooted in the enhanced safety, reliability, and visual appeal offered by underground power feeders, aligning to foster a conducive learning environment on campus.

Design and technical considerations for the proposed underground cabling system are paramount for ensuring its successful implementation. Factors such as equipment specification, route selection, cable types, safety measures, and environmental impact assessment must be carefully evaluated. These considerations are essential to guarantee the system's efficiency, reliability, and compliance with regulatory standards. Additionally, attention to detail in design and technical aspects is crucial for minimizing potential risks and ensuring seamless integration with existing infrastructure.

Moreover, a comprehensive cost analysis and effective cost management strategies are vital for determining the feasibility and sustainability of the project. Meticulous financial planning, strategic procurement practices, and innovative funding models significantly optimize resources and ensure cost-effectiveness. By carefully assessing the costs associated with undergrounding the distribution system, stakeholders can make informed decisions regarding resource allocation and prioritize investments that yield long-term benefits.

Overall, this research contributes valuable insights into the transition to underground power feeders in educational institutions, emphasizing the importance of comprehensive evaluation, meticulous planning, and effective cost management. These insights are pertinent to the CBSUA campus and have broader practical implications for stakeholders involved in similar projects across various educational institutions. By emphasizing the significance of these considerations, this research aims to guide stakeholders toward informed decision-making and facilitate successful implementation, ultimately enhancing the electrical infrastructure and fostering safer, more sustainable, visually appealing learning environments.

5 | RECOMMENDATION

Transitioning to underground power feeders in educational institutions necessitates a comprehensive approach encompassing informed decision-making, meticulous planning, and strategic financial management. These recommendations guide institutions seeking to implement underground power feeder systems efficiently and effectively.

Firstly, institutions must prioritize a thorough and inclusive decision-making process. This involves considering aesthetic preferences, environmental impact, safety, and regulatory compliance. Engaging stakeholders in decision-making ensures a well-rounded perspective and greater acceptance of the chosen system. Institutions can gather diverse insights and address potential concerns early in planning by involving faculty members, administrative staff, students, and external experts. Secondly, careful attention to design and technical considerations is paramount. Institutions should conduct detailed load analyses to determine the power requirements of different campus areas. Route selection should be based on terrain, accessibility, and potential disruptions. Additionally, selecting appropriate cables and incorporating safety measures are essential aspects of the design process. Conducting environmental impact assessments and ensuring compliance with regulatory standards are integral to responsible infrastructure development. Moreover, exploring the integration of renewable energy sources and backup power generation can enhance the sustainability and resilience of the electrical infrastructure.

Financial planning and cost management strategies are critical in successfully implementing underground power feeder systems. Institutions are encouraged to explore options such as bulk purchasing agreements to leverage economies of scale and reduce procurement costs. Alternative financing models, including public-private partnerships or leasing arrangements, can provide additional funding avenues. Collaborating with local authorities to access financial incentives or grants can alleviate the initial investment burden. Furthermore, prioritizing energy-efficient technologies aligns with environmental sustainability goals and contributes to long-term cost savings through reduced energy consumption and operational expenses.

In conclusion, a successful transition to underground power feeders in educational institutions requires careful consideration of decision-making, design, and financial management. By adopting a holistic approach and implementing these recommendations, institutions can navigate the complexities of infrastructure development while enhancing safety, reliability, and sustainability in their campus environments.

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