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Development of Mobile and Computer Application Based on Philippine Electrical Code (2017) for Single and Three-Phase Electrical Designing

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ABSTRACTS

This paper gives the design and development of an overall application for Electrical Design and Load Scheduling using the 2017 edition of the Philippine Electrical Code (PEC). The software is specially developed to aid engineers, electricians, and students in automating and streamlining the task of designing electrical systems of residential and commercial buildings. It offers essential computational resources that assist in PEC compliance as well as improved efficiency and precision in system planning. The program accommodates both Single-Phase and Three-Phase electrical systems and features an extensive array of capabilities, such as voltage drop analysis, load calculation, demand factor consideration, and safe branch circuit distribution. These capabilities are essential in avoiding overload, ensuring energy efficiency, and enhancing safety in electrical installations. The user interface is intuitive and easy to use, making it possible for even inexperienced individuals to carry out complicated electrical calculations with ease. Through the combination of smart computation and code compliance, the app combines theoretical knowledge with actual practice in electrical engineering.

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1. INTRODUCTION

The Philippine Electrical Code (PEC) is the main regulatory guide for safely installing electrical systems within the Philippines. It draws from the National Electrical Code (NEC) but adapts the concepts to suit local needs, focusing particularly on safety and system effectiveness (McAllister & McAllister, 2013). The PEC provides detailed guidelines on load capacity calculation, conductor sizing, voltage drop management, short-circuit protection, and grounding (Prabhu et al., 2016; Kasikci, 2018). These standards help engineers and technicians design reliable and safe electrical systems with a reduced risk of accidents and equipment failure. The PEC is also used to guide the design of load schedules for single-phase and three-phase electrical systems, ensuring installations are both safe and efficient (Yazdani et al., 2010). Key factors like conductor size, load distribution, voltage drop, and short-circuit protection are critical in preventing hazardous situations and optimizing system performance. Most electrical fires and accidents in the past have been caused by short circuits and overloaded circuits, highlighting the importance of proper load scheduling and compliance with PEC standards (Meegahapola et al., 2020; Chapin & Herman, 2023).

The conventional procedure of doing the computation manually of load schedules and preparation of panel board schematic diagram is tedious and prone to error (Liu et al., 2018; Kamilaris et al., 2014). The application, the researcher claims, should pass the Philippine Electrical Code for safety purposes. As an application in the Philippines, PEC is used to guide electrical equipment installations to be able to meet the requirements of safety. In the process, balance and efficiency in scheduling loads must be achieved between single-phase and three-phase systems. The voltage drops and short circuit cases must be considered against the working electrical systems that ensure high safety and reliability, particularly in countries such as the Philippines, due to its strict regulatory regime (Al-Shetwi & Sujod, 2018). Currently, electrical engineers said that three-phase balancing is time-consuming and may involve human errors (Lin et al., 2008). They would have to look for sophisticated software that is heavy in learning or do it manually, which would be very time-consuming and vulnerable to errors. The application for the electrical engineers should make it easier to perform load calculations, as requested by the Philippine Electrical Code. The application will best run much more smoothly in the electrical design system environments so that it may well be adaptable to many projects.

The overall aim of this research is to design an application for Electrical Design and Load Scheduling. The objective is to make calculations related to Single-Phase and Three-Phase loads automatic as well as compute Voltage Drops for Residential and Commercial buildings. The output should contain a One-Line Diagram, in which Short Circuits shall also be computed so that an amount of current flowing along the unintended path of an Electrical Circuit with no or very low Electrical Impedance could be calculated.

The study will explicitly aim to achieve the following goals:

1) Design an application especially Load scheduling for

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single phase and three phase that is user-friendly for Registered Electrical Engineers and Professional Electrical Engineers in planning and tracking their electrical loads in conformity with the Philippine Electrical Code 2017.

2) Design your electrical load schedule that will have ideal utilization of energy and time. Ensure that it would be compliant with the PEC 2017. Resources management—like electrical power, computing load schedule reduce working time and human error. Ensures output reliability.

2. METHOD

2.1. Research design

This paper shall adopt a design and development research design that shall focus on developing an application that shall be used in scheduling loads of single- and three-phase systems in residential and commercial buildings according to the Philippine Electrical Code standards. This phase encompasses the programmer aspect while development focuses on coding and backend functionality. It will include internal and user testing, after which refinement of features should happen, and in the evaluation phase compliance checks to ensure that it meets the code standards and is satisfying for the users.

2.2. Conceptual framework

The conceptual framework for the development of the PEC-based electrical design and load scheduling application is structured around three components: Inputs, Process, and Outputs (Kaymanesh et al., 2021). The Inputs consist of PEC standards such as breaker sizes, grounding specifications, and wire sizes, which are then processed to design an intuitive interface and automate calculations for load scheduling, leading to Outputs in the form of a functional application that provides PEC-compliant validation and tools for Registered Electrical Engineers and Professional Electrical Engineers to create accurate designs effectively without violating PEC standards (see Figs. 1 and 2).

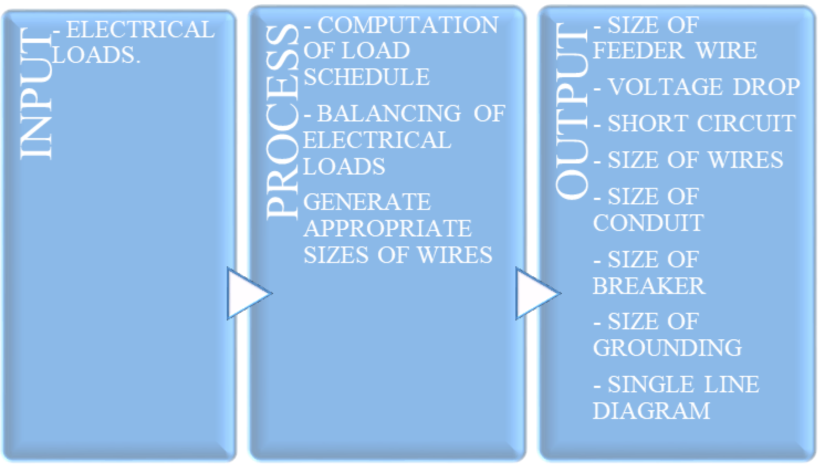

Fig. 1. Conceptual framework.

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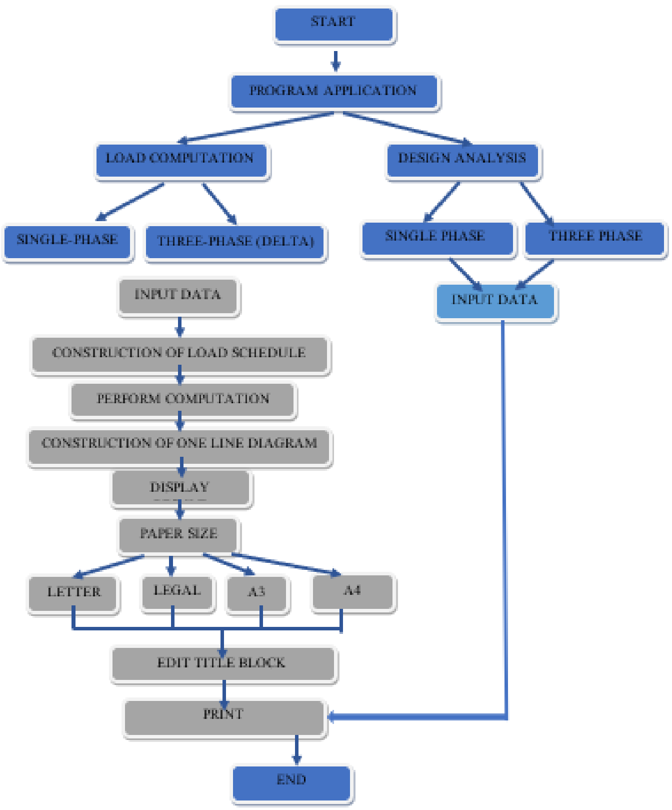

Fig. 2. System architecture.

2.3. Program Application

The program application offers a user-friendly interface where electrical engineers can input project specifications and load requirements for both single-phase and three-phase systems. The app ensures data privacy and security throughout the process, protecting the user's information and allowing for secure retrieval of saved files (Giffin et al., 2017; Sun et al., 2014). Once registered, users can easily access tools for load scheduling, system design, and short-circuit analysis, all while adhering to PEC standards and ensuring the safety and efficiency of electrical systems.

2.4. Single-Phase System

In a single-phase system, the service entrance conductors refer to the cables connecting the load side of the meter to the house or building, and the service equipment, typically including circuit breakers and fuses, ensures safe operation by controlling the power supply. The formulas for computing the service entrance conductor size (IF) and the size of the breaker (IMCB) are based on factors such as load demand, grounding, and the highest rated motor load (HML), ensuring compliance with safety standards for residential applications.

2.5. Three-Phase System

In a three-phase system, a delta connection is a method where three elements form a triangle, and the supply is provided at the junctions. The system calculates key parameters like the ampacity of feeder conductors, line currents, and the current of the highest rated motor in the group. These

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calculations ensure the effective distribution of power across large commercial or industrial applications by considering factors such as motor ratings, line current summations, and the correct configuration of the feeder conductors (Tolbert, 2005; Gönen et al., 2024).

2.6. Input Data and Load Scheduling

The input data for the application involves selecting the program and entering the required load type and other relevant parameters, with drop-down menus for easier input and data verification. The load schedule constructed by the user will include vital details such as wire and conduit sizes, circuit breaker ratings, and circuit numbers, which are essential for the designer to calculate backup power requirements and ensure compatibility with the electrical system, whether it is single-phase or three-phase.

2.7. Computation and One-Line Diagram

The computation process utilizes the data in the load schedule table to determine the proper wire sizes, conduit specifications, and breaker ratings for each load (Azevedo et al., 2009). This information then feeds into the construction of a one-line diagram, which represents the key components such as the service entrance, breaker sizes, grounding wire, and trip settings for the circuit breakers. This diagram ensures that all components are designed according to the Philippine Electrical Code (PEC) and are safe and compliant for installation.

2.8. Voltage Drop and Results

The application also calculates voltage drop, which occurs when current flow is impeded, leading to reduced current and potential issues with the electrical system. The result section displays detailed information, such as wire sizes, conduit ratings, and circuit breaker specifications for all loads, along with the one-line diagram that includes circuit numbers and grounding details. This section ensures that the design meets safety standards and is ready for installation.

2.9. Saving Data and Short Circuit Computation

Once the design is complete, users can save the results as a text file containing the load schedule and one-line diagram, with options for printing in various paper sizes or converting the file to PDF. Short-circuit computation is also integrated into the program to calculate the potential fault current, ensuring that the protective devices like circuit breakers are properly sized to handle fault conditions and prevent electrical disasters.

2.10. Testing and Evaluation

Testing and assessment of the load scheduling application's functionality, usability, and efficacy will be done on the mobile app. Functional testing will determine whether it meets the requirements of the Philippine Electrical Code (PEC) for short circuit analysis, voltage drop analysis, and load calculations. User experience would be included from the usability point of view that is, getting feedback on user interface during usability testing, and so on. Finally, through performance testing, it could assess the performance of applications in terms of how responsive an application is towards users when they are needed to have a stable execution without fluctuations in resource

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utilization. Field testing will test whether the app indeed works by simulating realistic residential as well as industrial conditions under which it shall be running and monitoring how it alters energy consumption, efficiency with which electrical power systems handle the load in that real scenario.

2.11. Implementation Plan

After testing and revision, the application will be made available with a secure verification process that will restrict access to only Professional Electrical Engineers and Registered Electrical Engineers. To ensure users' continuous compliance and relevance, the app will be updated with the future changes to the Philippine Electrical Code.

2.12. ISO/IEC 25010

The ISO/IEC 25010 standard is a valuable tool for assessing the PEC-based electrical design and load scheduling application. It ensures the application meets functional suitability by accurately calculating load schedules, breaker sizes, and voltage drops according to the Philippine Electrical Code (PEC). The performance efficiency criterion ensures the app handles complex tasks quickly and accurately, even for large systems, while compatibility ensures it works across platforms and outputs data in various formats. Following these standards ensures the application is reliable, efficient, and compliant with PEC regulations.

2.13. Data Gathering

Using a user-centered methodology, this study will collect specific thoughts and feedback from Registered Electrical Engineers and Professional Electrical Engineers through interviews and group discussions. Semi-structured interviews provide an extensive analysis of each participant's requirements and expectations regarding load scheduling and Philippine Electrical Code compliance. Discussion on the design of the application will be facilitated through group discussion and hence cooperative discussion and brainstorming on specific features, usability of the interface, and checks on compliance. Changes to the app functionality, interface, and PEC compliance will thus be made based on feedback from iterations of the final product for it to meet the needs and preferences of its users.

3. RESULTS AND DISCUSSION

Table 1 displays the participants of the research. The research respondent for this study is carefully selected, ensuring well – rounded and accurate evaluation of subject matter. The gathered data is organized to show the number and percentage of respondents in two groups: "1 PEE" and "9 REE (with three years of design experience)". It is evident from the table that a total of 10 participants were in the study. A vast majority of the participants in this group (9 out of 10, or 90%) are in the "REE" category, with a remarkable three years of experience as designers. The smaller minority (1 out of 10, or 10%) fall into the "PEE" category. The difference in representation of the groups indicates a possible emphasis on experienced professionals from the perspective of designers in the scope of the research (see Table 2).

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Table 1. Respondents of the Evaluation

SCALE	RANGE	DESCRIPTION
1	1.00 – 1.49	Not at all Satisfied
2	1.50 – 2.49	Partly Satisfied
3	2.50 – 3.49	Satisfied
4	3.50 – 4.49	More than satisfied
5	4.50 – 5.00	Very Satisfied

Table 2. Five Point Likert Satisfaction Scale.

RESPONDENTS	FREQUENCY	PERCENTAGE
1 PEE	1	10%
9 REE (WITH 3 YEARS OF EXPERIENCE IN DESIGNING)	9	90%
TOTAL	10	100%

Table 2 shows the results of an evaluation based on the ISO/IEC 25010 standard. The evaluation of the Electrical Engineering Design Application considered several indicators of software quality, such as Functionality, Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, and Portability. The information is organized to reveal the number of respondents who have given each indicator a rating of 1 through 5 on a 5-point scale with 5 representing the highest mark, as well as the aggregate number of replies, the mean, median, and mode of each indicator. Response description ("Very Satisfied," "More Than Satisfied") is given for each indicator from the grouped scores (see Table 3).

Table 3 shows that overall, the largest number of respondents provided high scores of satisfactions. For instance, Functionality and Usability both had mean scores of more than 4.8, reflecting a very high level of satisfaction. Security, however, has a low mean score of 3.9, reflecting areas for possible improvement. The mode clearly reflects a high level of satisfaction (score of 5) for most of the indicators, highlighting the positive feedback overall. The overall number of responses across all the indicators is 358, giving a large data set for analysis. The last row condenses the overall results into an overall mean score of 4.5, a median of 5, and a mode of 5, all indicating a high degree of overall satisfaction with the system being evaluated. More detailed analysis might discuss the reasons for the lower rating

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on Security and consider the possible consequences of such results.

Table 3. Overall Result of the ISO/IEC 25010.

INDICATORS	RESPONDENTS					TOTAL	MEAN	MEDIAN	MODE	RESPONSE DESCRIPTION
	1	2	3	4	5					
FUNCTIONALITY SUITABILITY	0	0	0	12	35	47	4.7	5	5	VERY SATISFIED
PERFORMANCE EFFICIENCY	0	0	0	20	25	45	4.5	5	4	VERY SATISFIED
COMPATIBILITY	0	0	6	12	25	43	4.3	5	5	MORE THAN SATISFIED
USABILITY	0	0	0	8	40	48	4.8	5	5	VERY SATISFIED
RELIABILITY	0	0	3	8	35	46	4.6	5	5	VERY SATISFIED
SECURITY	0	0	9	20	10	39	3.9	4	4	MORE THAN SATISFIED
MAINTAINABILITY	0	0	6	16	20	42	4.2	4	4	MORE THAN SATISFIED
PORTABILITY	0	0	0	8	40	48	4.8	5	5	VERY SATISFIED
INDICATOR	RESPONDENTS					TOTAL	MEAN	MEDIAN	MODE	RESPONSE DESCRIPTION
	1	2	3	4	5					
TOTAL	0	0	24	104	230	358	4.5	5	5	VERY SATISFIED

4. CONCLUSION

This study developed a mobile and computer application based on the 2017 Philippine Electrical Code (PEC) to assist in designing single-phase and three-phase electrical systems. The application automates load scheduling, voltage drop

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computation, short-circuit analysis, and one-line diagram generation. It is intended to help Registered and Professional Electrical Engineers improve efficiency, ensure accuracy, and comply with PEC standards. Based on the evaluation results, users expressed a high level of satisfaction with the application across all quality indicators. Feedback highlighted the application's effectiveness, usability, and reliability in supporting electrical system design. These results indicate that the tool successfully meets user needs and expectations, reinforcing its value as a practical solution for ensuring compliance with the 2017 Philippine Electrical Code.

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