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**THE IMPACT OF ARTIFICIAL INTELLIGENCE (AI)
ON THE ELECTRICAL SYSTEMS IN BUEA-
CAMEROON**

Master Thesis

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SUMMARY

The aim of this study is to investigate the impact of artificial intelligence (AI) on the energy sector in Buea, Cameroon. This study adopted a cross-sectional research design. The source of the data for this study was collected by distributing a questionnaire to 333 participants sampled through simple purpose sampling. Inferential statistics were used for analysis, and graphs, tables, frequencies, percentages, averages and standard deviations were used to explain the statistics. Research results show that 34.2% of energy changes can be predicted by artificial intelligence (AI). In particular, ENEO experts in Cameroon and families in the city of Buea had a positive/significant value of 0.706 regarding energy efficiency; ENEO Cameroon and non-standard energy supply (PPP) of households in Buea city has a positive/significant impact of 0.254 energy, 0.070 energy at the same time. Based on the findings, the study concluded that the combination of experts, fuzzy systems and non-standard electronic devices leads to success in the fire force. This study recommends that ENEO Cameroon and its family should strengthen the use of specialists, fuzzy systems and the use of non-standard energy sources for monitoring fire energy electricity.

Keywords: Artificial Intelligence (AI); Electrical Systems; (Expert System (ES); Fuzzy System (FS) and Artificial Neural Network (ANN).

ÖZET

Bu çalışmanın amacı Yapay Zekanın (AI) Buea-Kamerun'daki elektrik sistemleri üzerindeki etkisini incelemektir. Bu çalışma kesitsel bir araştırma tasarımını benimsemiştir. Bu çalışma için birincil veri kaynağı, basit amaçlı örnekleme tekniği ile örneklenen 333 katılımcıya anketlerin dağıtılması yoluyla toplanmıştır. Analiz için çıkarımsal istatistikler, tanımlayıcı istatistikler için ise çubuk grafikler, tablolar, frekanslar, yüzdelere, ortalama ve standart sapmalar kullanıldı. Çalışmanın sonucu, elektrik sistemlerindeki varyasyonun %34,2'sinin Yapay Zekadan (AI) tahmin edilebildiğini ortaya koyuyor. Spesifik olarak, ENEO Kamerun'daki uzman sistemler ve Buea Belediyesi'ndeki haneler elektrik sistemini 0,706 oranında olumlu/önemli bir şekilde etkilemektedir; ENEO Kamerun'daki bulanık sistemler ve Buea Belediyesi'ndeki haneler, elektrik sistemini 0,254 oranında olumlu/önemli bir şekilde etkilerken, ENEO Kamerun'daki Yapay Sinir Ağı (YSA) ve Buea Belediyesi'ndeki haneler, elektrik sistemini 0,070 oranında olumlu/önemsiz bir şekilde etkilemektedir. Bulgulara göre çalışma, uzman sistemler, bulanık sistemler ve yapay sinir ağlarının entegrasyonunun elektrik sistemlerinde önemli ilerlemeler sağladığı sonucuna varmaktadır. Çalışma, ENEO Kamerun ve hanelerin uzman sistemlerin, bulanık sistemlerin uygulanmasını güçlendirmesi ve elektrik altyapısının tahmine dayalı bakımını için YSA'ların konuşlandırılmasını önermektedir.

Anahtar Kelimeler: Yapay Zeka (AI); Elektriksel sistemler; (Uzman Sistem (ES), Bulanık Sistem (FS) ve Yapay Sinir Ağı (YSA)).

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ABBREVIATIONS

AI	:	Artificial Intelligence
FS	:	Fuzzy System
ES	:	Expert System
FIS	:	Fuzzy Interface System
ANN	:	Artificial Neural Networks
GOFAI	:	Good Old-Fashioned AI
PDP	:	Parallel Distributed Processing
RL	:	Reinforcement Learning



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PREFACE

The integration of artificial intelligence (AI) in many fields is advancing rapidly and revolutionizing the world. In the energy sector, technology has the potential to transform operations, increase efficiency and improve resource utilization. This study aims to evaluate the impact of artificial intelligence on Cameroon's energy sector. Cameroon faces unique challenges and opportunities in the energy sector and will benefit greatly from the integration of technological expertise. Using machine learning algorithms, predictive analytics, and automated systems, it is possible to simplify operations, improve maintenance, and increase the reliability of entire networks.

This study focuses on an in-depth examination of the current situation of Cameroon's electricity sector, investigating existing systems, management models and good functioning. By analyzing research data, conducting research, and collaborating with industry experts, this research focuses on a comprehensive assessment of how brilliant the use of technology is and the problems and opportunities it presents. This study, which is a scientific and legal research, aims to provide recommendations to stakeholders in the Cameroonian electricity sector. Ultimately, this research aims to unlock the transformative potential of artificial intelligence to modernize Cameroon's energy sector and pave the way for a stronger and more efficient future. Making informed decisions, guiding business practices and driving greater innovation in Cameroon's energy industry using artificial intelligence. As we begin to explore the impact of artificial intelligence on electronic systems, we are poised to unlock new possibilities and create a future where machines work together to drive progress and sustainability.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The main purpose of this study was to assess the impact of artificial intelligence (AI) on the energy sector in Buea, Cameroon. This book is divided into five parts. Chapter 1 is an introduction that includes the research background, problem statement, research questions and objectives, research hypotheses, research findings, main focus of the research, and content of the study. Chapter 2 reviews the literature relevant to this study. It includes a review of research content, a theoretical analysis, a review of evidence and finally an analysis of different studies and contributions. Chapter 3 describes the methods used to conduct the research, including the research design, research area, population survey, sampling and sampling methods, data collection and analysis tools, data collection, data analysis techniques, and ethical decision making. Chapter 4 presents the findings, and Chapter 5 provides discussion, conclusions, recommendations, and recommendations regarding potential areas for further research.

1.2 Background to the Study

Nowadays, the growth of electricity systems in terms of both size and complexity indicates the importance of achieving a high level of security system. At the same time, modern electronic devices perform complex tasks and reach their limits (Rastgoufard et al., 2016; Kalyani and Swarup, 2011). Therefore, it is obvious that due to these high demands the system will easily break down with a minor disturbance (Niazi et al., 2004). Therefore, fast and accurate online monitoring standards are required to prevent equipment damage, local power outages, blackouts, frequency drops, or serious electrical injuries (Morison et al., 2005). Security monitoring, contingency analysis, and security management are three important steps of security assessment. In safety monitoring, the work is directed to the working engineers. In incident analysis, events are filtered and analyzed to minimize their severity. In the security control step, operational control is taken to secure the vulnerable process (Sekhar and Mohant, 2016).

The use of artificial intelligence (AI) to solve energy problems has increased in recent years. Combining machine learning, data mining, and evolutionary algorithms can be a great solution

for instant security assessment. Modern methods have been shown to provide better results and often show faster response times compared to traditional methods (Rastgoufard et al., 2016).

In the twenty-first century, artificial intelligence has become one of the most adopted technologies in many fields (Salloum et al., 2020). The UAE is the first country in the region and even in the world to develop an intelligence strategy; This shows that there is a lack of adoption of intelligence in the government's strategic plan (Aburayya, 2020). China, the USA, the UK, France and many other countries have included intelligence in their development plans. The main reason for using skills is to integrate various fields such as health, energy/renewable energy, finance, water, education and environment. Artificial intelligence is the development of systems through the use of technology and software to represent human cognitive processes, thoughts and abilities. Electrical engineering involves the creation, transmission, distribution, and use of electricity and various electronic products (Yousuf et al., 2021). Access to renewable energy makes it difficult for modern equipment to exhibit different conditions due to its complexity. Electronic analysis must process complex, diverse, and large amounts of data for computational, diagnostic, and educational purposes. Technologies such as computers can solve complex problems related to energy planning, operation, design and diagnosis (Shanna et al., 2012; AlShurideh et al., 2019). Therefore, artificial intelligence helps manage the process of processing large and big data and provides accurate and timely information to make the right decision in solving energy problems and improving energy electricity (Yousuf et al., 2021).

The world is increasingly concerned about the environmental impact of the electricity sector, where electricity is produced by factories (using gas and coal) and sent via wires to end users. Artificial intelligence increases the security of the energy sector by combining technology with renewable energy to create clean energy. An example of the use of sustainable practices in the electricity sector is the decentralized panels in the system, helping to provide good and clean energy to the system. Many studies have recently been conducted to measure improvements in security by incorporating artificial intelligence into systems. For this reason, artificial intelligence applications have attracted more attention

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In recent years, many studies have focused on the use of smart technology in energy systems, including smart grids and renewable energy sources such as solar and wind turbines (Yousuf et al., 2021). Four main AI technologies are widely used: artificial intelligence, fuzzy logic, genetic algorithms and neural networks. Depending on the situation, hybrids of these systems have emerged. All systems support solutions in electronic systems. AI can also reduce maintenance and operating costs. Additionally, artificial intelligence increases the efficiency of the electricity or energy sector, including electricity and renewable energy. Artificial intelligence can manage planning, control, monitoring and forecasting tasks (Yousuf et al., 2021). It is necessary to determine the appropriate artificial intelligence technology when planning, monitoring and controlling electrical systems. Additionally, this system increases electrical performance and efficiency by controlling electricity, safety, energy flow and load frequency. It also allows network management such as location, size, and control of devices and equipment. Provides support for automation of electronic systems, recovery, diagnostics, management and cybersecurity. Another important factor is accuracy and instant forecasts, forecasts and predictions that enable the power plant to effectively manage its resources and meet demand. Artificial intelligence technology controls environmental safety and enables the energy sector to

move towards sustainable development by introducing various methods together with renewable energy (Yousuf et al., 2021).

In general, intelligence is considered to be the intelligence displayed by machines and software (such as robots and computers). The term is often used for projects that create machines that have the characteristics and properties of human cognitive processes, such as the ability to think, feel needs, discover meaning, express broadly, differently, learn from experience, or make mistakes. Artificial General Intelligence (AGI) is the intelligence of a hypothetical machine or computer that can perform any cognitive task that a human can perform. Electronic analysis using traditional methods is becoming more difficult due to the complexity, comprehensiveness and volume of data used in calculation, diagnosis and education and the increase in calculation time and accuracy (Pasupathi and Nishanth 2002).

The use of artificial intelligence (AI) in Cameroon has the potential to impact Cameroon's energy sector, transforming all aspects of electricity generation, transmission, distribution and use. AI systems can analyze historical data, weather patterns, business metrics, and user behavior to accurately predict electricity demand. This information helps Cameroonian electricity companies optimize their generation and distribution plans, thus reducing electricity waste and saving costs (Galvanin and Canizes, 2018). Regarding the optimization of the smart grid, intelligence can improve the efficiency and reliability of the grid through proper operation and maintenance. Machine learning can analyze real-time data from smart meters, meters, and other grid devices to detect anomalies, predict failures, and ensure good energy flow. This leads to better monitoring, detection of errors, and faster recovery in case of disaster (Li et al., 2017). . Smart home devices equipped with smart appliances can analyze usage patterns and adjust settings to optimize energy use. This helps save energy, reduce expenses, and increase awareness of sustainable practices (Khan et al., 2019). As electronic systems become more complex, AI can improve grid security and prevent cyber threats. Machine learning algorithms can analyze network traffic, identify patterns and instantly detect potential security threats or vulnerabilities. This increases the strength of the network and protects important processes (Uluagaç and Beyah, 2019). Following many discussions in the literature regarding artificial intelligence, there is a need to investigate the impact of artificial intelligence (AI) on the energy sector in Buea, Cameroon.

1.3 Statement of the Problem

The rapid adoption of artificial intelligence (AI) has had a major impact on Cameroon's energy sector. As artificial intelligence technology becomes widespread in many sectors from production to transportation, electricity demand also increases. This increased demand has created many challenges for Cameroon's electricity supply; This resulted in darkness, increased energy consumption and disruption of the entire energy supply. Moreover, artificial intelligence applications such as smart grids and autonomous systems in the energy sector bring new challenges that need to be addressed to ensure good security and efficiency of Cameroon's electricity (Ngouateu et al., 2020). However, in Cameroon, consumers often encounter problems when paying their electricity bills. These problems can be attributed to many factors, such as inadequate infrastructure, limited payment options, and intermittent electricity (Nde et al., 2018). Similarly, customers often face a lack of convenient payment methods. In general, payment methods such as mobile banking and online platforms are not widely used and customers are not left with options such as paying in cash at physical collection points or transferring their bank accounts (Asongu and Nwachukwu, 2017). Similarly, irregular use of electricity in Cameroon also affects the payment process. Consumers may receive high electricity bills because the distribution system cannot calculate electricity usage time correctly (Ketter et al., 2013). Similarly, consumers are often unaware of the electricity bill payment process or do not understand the importance of paying their bills on time. This situation leads to lack of cooperation and payment delays (Tchouatieu., 2014).

Despite the competition, demand for and payment for Cameroon's electricity has increased with the introduction of skills, people can pay their bills directly from their homes, and some indicators have been adjusted for easy billing and maintenance. and control. According to a study by Ngouateu et al. (2020), the introduction of artificial intelligence in the electricity industry has increased the demand for electricity, putting pressure on Cameroon's existing infrastructure.

Despite the challenges faced by the energy sector, the use of smart technologies such as fuzzy electronics, fuzzy systems and experts are being used to solve some of the above problems. In light of this, this study aims to investigate the impact of information on energy in Buea, Cameroon.

1.4 Research Questions

The main research question of this study is; what is the impact of Artificial Intelligence (AI) on electrical systems in Buea-Cameroon.

The various specific research questions the study includes;

- To what extent does expert system affect electrical systems in Buea-Cameroon?
- What is the impact of fuzzy system on electrical systems in Buea-Cameroon?
- How does artificial neural network affect electrical systems in Buea-Cameroon?

1.5 Objectives of the Study

The main objective of this study is to examine the impact of Artificial Intelligence (AI) on electrical systems in Buea-Cameroon.

The specific objectives of the study include;

- To investigate the impact of expert system on electrical systems in Buea-Cameroon.
- To evaluate the impact of fuzzy system on electrical systems in Buea-Cameroon.
- To analyze the impact of artificial neural network on electrical systems in Buea-Cameroon.

1.6 Hypothesis of the Study

H₀₁: Expert system has no significant impact on electrical systems in Buea-Cameroon

H₀₂: Fuzzy system has no significant impact on electrical systems in Buea-Cameroon

H₀₃: Artificial neural network has no significant impact on electrical systems in Buea-Cameroon

1.7 Scope of the Study

The proposal covers the impact of artificial intelligence (AI) on electricity in Buea, Cameroon. The different artificial intelligence (AI) methods used in this study are expert, fuzzy machines, and cognitive systems. These changes were chosen to examine the impact of the Buea Electricity Company (ENEO) in Cameroon.

In terms of geographical area, the study focuses on Buea, Fako Region and Cameroon. This particular city was chosen because it was easily accessible and easier to collect data from. In terms of time, the study is expected to be completed within one year from the school calendar. However, some limitations were encountered during the writing process of the research article. This is included. First, researchers have limited access to the information needed to conduct the study, and the timeframe for completion of the study is also an issue in this study.

1.8 Significance of the Study

This study is significant in several dimensions relating to academics, companies concern researchers and the student.

First, this research is relevant to the Eneo Cameroon because the research needs to reveal the role of intelligence in the development of electricity, as stated in the problem statement. Based on this, good management decisions can be made in this area to improve the company's processes and processes to improve their technology and enable them to choose the right AI technology to overcome competitors and meet customer needs as business environment changes.

This research in education contributes to the knowledge of the academic community, enables future researchers to refer to it, and helps reduce the current information technology gap in the literature.

The research findings are also useful for future research to understand how businesses can use AI technology to gain competitive advantage and improve fire suppression systems. He has talent. Moreover, this study is very important for the researcher because it is expected to be completed and become a requirement for the award of the master's degree.

This research is also relevant to the public because it allows the public to learn about the necessary intellectual property that can be used in other ways to improve energy. Therefore, it is hoped that this article will serve as a reference for students, young researchers and the general public interested in this research. Cameroon is a country committed to economic development and prosperity, and energy is a symbol of sustainable development. With the development of today's world, the use of electronic devices has become an important issue to compete.

Therefore, the use of electronic skills is important for today's organizations, which makes the choice of this topic because it is necessary for today's organizations.

1.9 Operational Definition of Terms

Artificial Intelligence

Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems (Britannica, 2021). It can also be defined as the theory and development of computer systems able to perform tasks that normally requires human intelligence (Stuart and Peter, 2009).

Electrical System

An electrical system is a network of interconnected components that are designed to generate, transmit and distribute electrical energy (Charles, 2007). They are equally regarded as electrical devices and networks that are designed to perform specific functions such as power generation, distribution and control (Allan, 2013).

Fuzzy System

The fuzzy system is a system that helps to increase the voltage profile of the power system. It permits to convert the voltage deviation and comparing variables into fuzzy system notions. Fuzzy logic backs to obtain reliable, constant, and clear output because normally, power system investigation employs approximate values and assumptions (Nath and Balaji, 2014).

Expert System

Expert systems are systems that applies Boolean logic, intelligent computer programming. It sanctions to transplant human expertise in specific areas to solve the issues as a human being (Salloum et al., 2018). That is, it replaces human experts in some particular fields (Salloum et al., 2017).

Artificial Neural Networks (ANNs)

The artificial neural network is a biologically influenced system because the wiring of neurons converts the inputs to outputs. So, every neuron generates one output as a purpose of the input.

While analyzing with other techniques such expert system, the neural network is known as a generic sort of AI because it imitates the human brain with the assistance of the command (Yousuf et al., 2021).



CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is concern with the review of literature relating to the concepts used in the study. The chapter is divided into four sub sections and comprise of the conceptual review, the theoretical review, review of empirical literature and ends by establishing a gap and bringing the potential contribution to close the gap.

2.2 Conceptual Review

2.2.1 Artificial Intelligence (AI)

Concurring to LeCun, (2019) AI is the advancement of computer frameworks that can perform assignments that would ordinarily require human insights. Similarly, Li (2018) expressed that AI investigate changes how we get it our claim insights.

Also Pearl, (2009) expressed that AI is concerned with empowering machines to reason, learn and make choices. Within the same line Schalkoff (1992) characterized AI as the study of how to form computers do things at which at the minute individuals are way better.

In expansion as clarified by Kurzweil (2005), AI is the science and designing of making computers as shrewd as people. Essentially, Horvitz (2000) expressed that AI considers computational models of human behavior and insights.

More so, Thrun and Norvig (2010) clarified that AI involves considering and building frameworks that can act independently. Hassabis (2015) too clarified that AI alludes to the endeavor of building specialists that can perform assignments requiring insights. Within the supposition of Stuart and Dwindle (1995), AI is the ponder of operators that get percepts from the environment and perform activities.

Furthermore, Andrew (2017), clarified that AI comprises of building machines capable of performing assignments that would require insights on the off chance that performed by people. Within the words of Rodney (1999), expressed that AI approaches the issue of building cleverly machines with diverse presuppositions than does the rest of computer science.

Moreover, Fake insights is the reenactment of human insights forms by machines, particularly computer frameworks (Britannica, 2021). It can moreover be characterized as the hypothesis and advancement of computer frameworks able to perform assignments that ordinarily requires human insights (Stuart and Dwindle, 2009).

Artificial insights is known to be the insights displayed by machines and program, for illustration, robots and computer programs. It refers to the extent of creating frameworks prepared with the mental forms highlights and characteristics of people, just like the capacity to think, reason, discover the meaning, generalize, recognize, learn from past involvement or amend their botches. Manufactured common insights (AGI) is the insights of a hypothetical machine or computer which can finish any mental task effectively which a human being can fulfill (Pasupathi and Nishanth, 2003).

Artificial insights may be a department of computer science that centers on making intelligent systems that can perform assignment regularly requiring people cleverly. Manufactured Insights has developed transcendently in later a long time and has been connected to different ranges of control frameworks. Nowadays the most AI strategies found in electrical framework application utilizing the rationale and information representation of master frameworks, fluffy system, artificial unbiased organize and more as of late developmental computing. For the reason of this think about, the AI procedures utilized within the think about incorporates master framework, fluffy framework and information base framework as advocated within the writing from the work of (Yousuf et al., 2021 and Pasupathi and Nishanth, 2003). These AI methods are inspected assist.

2.2.1.1 Expert System (ES)

An expert system acquires the knowledge of a human expert in a narrowly specified domain into a machine-implementable form. Expert systems are computer programs that have expertise and competence in a certain area. This knowledge is generally stored separately from the procedural part of the program and can be stored in one of many forms, such as rules, decision trees, models, and frameworks. They are also called as knowledge-based systems or rule-based systems. Expert systems use interface mechanism and knowledge to solve problems that cannot or are difficult to solve by human skill and intellect (Pasupathi and Nishanth, 2003).

Expert systems are advantageous because they are durable and consistent, easy to document, and easy to transfer or reproduce. However, the disadvantage of expert systems is that they cannot learn or adapt to new problems or situations. Expert system applications in electrical systems correspond to expert system capabilities such as decision making, knowledge archiving, and problem solving through reasoning, heuristics, and judgment. Expert systems are especially useful for these problems, when it is necessary to process a large amount of data and information in a short period of time (Pasupathi and Nishanth, 2003).

Expert systems use Boolean logic, intelligent computer programming. It allows transplanting human knowledge in specific areas to solve problems as a human being (Salloum et al., 2017). This means that it replaces human experts in some specific fields (Salloum et al., 2018; Zu'bi et al., 2012). ES is still widely used in automation in other industries, its use in electrical systems and power electronics is limited. The basic elements of ES embody the knowledge or expertise base. Expert knowledge and database knowledge are two parts of a knowledge base that includes data, facts and other statements related to expert knowledge (Alshurideh et al., 2012). That is, the location of the human knowledge interface program is in the knowledge base. The figure below shows the structure of the expert system.

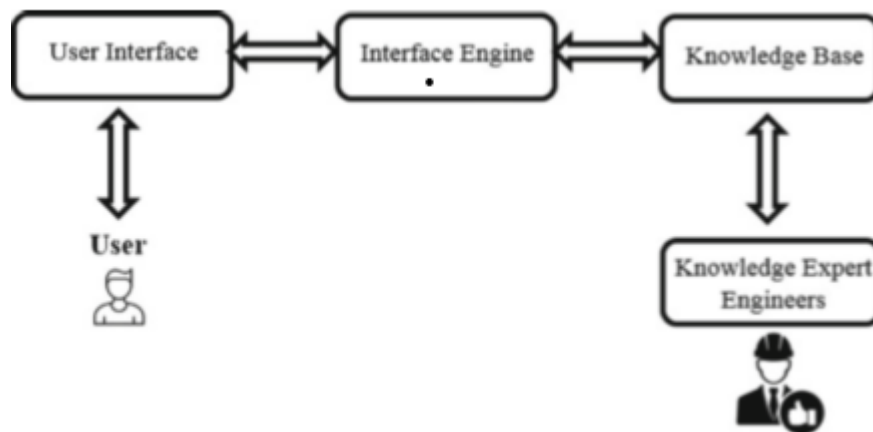


Figure 1. Structure of the Expert System

Source: Yousuf et al. (2021).

The process of writing codes for expert systems is simpler than calculating and estimating the value of parameters used in generation, transmission and distribution. Modifications are easy because they are computer programs. Further research can be done to increase the efficiency of

the process. The application of expert system in electrical system is to facilitate decision making, solve issues based on reasoning, judgment and heuristics, collection of knowledge and handles complex and extensive data and information.

2.2.1.2 Fuzzy System (FS)

The Fuzzy System (FS) is a system that helps to growth the voltage profile of the energy device. It allows to convert the voltage deviation and evaluating variables into fuzzy system notions. Fuzzy logic backs to achieve reliable, regular, and clear output because commonly, energy device research employs approximate values and assumptions (Nath and balaji, 2014). Fuzzy good judgment code favors controlling mechanical enter. It utilizes software or hardware mode from easy circuits to mainframes.

Fuzzy logic or Fuzzy systems are logical structures for standardisation and formalisation of approximate reasoning. it's miles similar to human decision making with an ability to provide precise and accurate answers from certain or maybe approximate records and records. The reasoning in fuzzy logic is much like human reasoning. Fuzzy logic is the way like which human brain works, and we can use this era in machines so that they can perform relatively like people. Fuzzification offers advanced expressive energy, higher generality and an stepped forward functionality to model complicated problems at low or slight solution value (Pasupathi and Nishanth, 2003).

Fuzzy good judgment permits a selected level of ambiguity during an analysis. because this ambiguity can specify available facts and minimise problem complexity, fuzzy good judgment is beneficial in many packages. For electrical structures, fuzzy common sense is appropriate for applications in many regions in which the to be had statistics entails uncertainty. as an example, a hassle might involve logical reasoning, but can be implemented to numerical, apart from symbolic inputs and outputs. Fuzzy common sense provide the conversions from numerical to symbolic inputs and back once more for the outputs (Pasupathi and Nishanth, 2003).

The fuzzy interface device (FIS) has five stages in implementation namaely; fuzzification of input variables (Define fuzzy variables), software of a fuzzy operators (AND, OR, not) in the IF rule, Implies IF after which, aggregates the outcomes and defuzzification to transform FIS output to price that is illustrated in parent under.

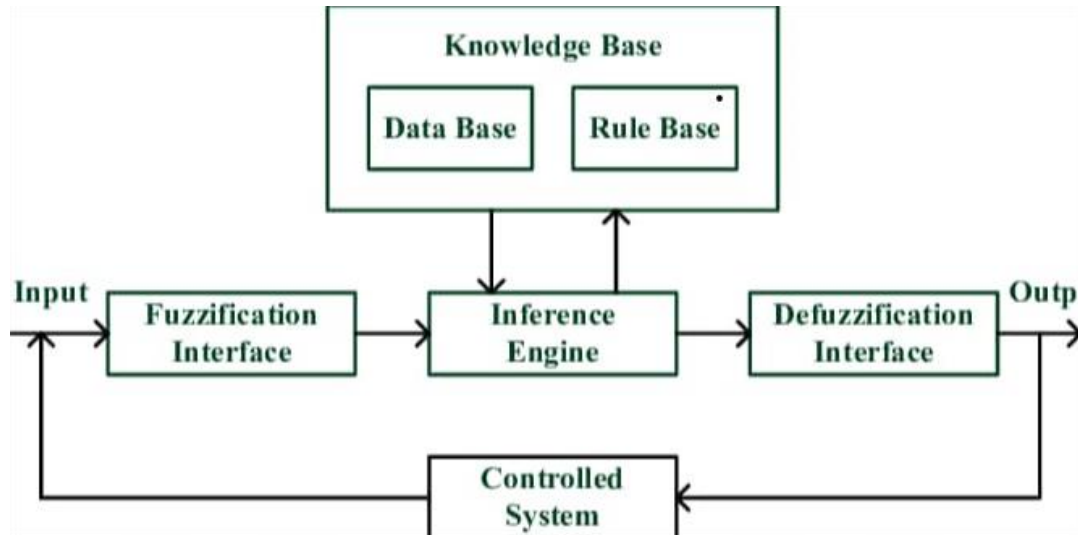


Figure 2. Structure of the Fuzzy System

Fuzzy logic can be used to design the physical properties of a power system. They can be used in everything from small circuits to large mainframes. They can be used to increase the value of materials used in electronic systems. Since most of the data used in electrical engineering is guesswork and assumption, fuzzy logic is useful to provide stable, precise and clear results.

The application of fuzzy logic in power systems is to provide power control, fault diagnosis, stability analysis and improvement, security assessment, load estimation, state estimation and energy planning and control. Fuzzy logic deals with reasoning and decision-making in situations of uncertainty and ambiguity. Unlike classical binary logic, which relies on true/false values, fuzzy logic allows for partial truth values or membership in a continuum of possibilities. It allows machines to process ambiguous or ambiguous data and make decisions based on a non-trivial level of accuracy.

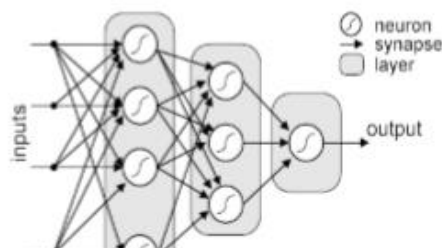
2.2.1.3 Artificial Neural Networks (ANNs)

A neural network is a biological system because connections between neurons transform input into output. Therefore, each neuron produces an output for feedback purposes. Neural networks, when identified with other technologies such as experts, are called general intelligence because they activate the human brain with the help of commands. Features similar to the nonlinear input-output mapping of pattern recognition exist in neural computer systems (NNW). Therefore, it can simulate the associative memory of the human brain. Therefore, artificial neural networks

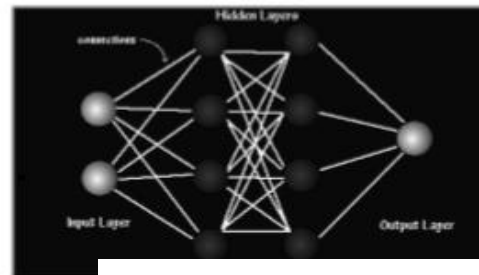
are an important part of artificial intelligence and can effectively solve problems related to pattern recognition or image processing. It is difficult to solve the information problem of this model in the traditional system (Bose, 2017).

ANN Interconnected artificial neurons can solve many problems related to science, engineering and real life. ANN is characterized as support or feedback design, depending on the direction of signal flow. The use of multilayer information (MLP network or three-layer feedforward, backpropagation) mode is very obvious. ANN provides three input strategies in the input layer and the output signal with scaling and scaling in the output layer. While the input and output processes of neurons have activation functions, central processing has a deactivation function (Bose, 2017).

Understanding the function and connectivity patterns of neurons can be used to design real-world classification models and computer programs to solve pattern recognition problems. They are classified by architecture: number of layers and topology: connection type, feed forward or loop. The picture below shows this.



Architecture of a feedforward ANN



Typical structure of an ANN

Figure 3: Structure of Artificial Neural Networks

Source: (Pasupathi and Nishanth, 2003).

The advantage of using neural networks is that they work fast and do not need good process knowledge, they have the ability to solve cases of missing data and misinformation, they are fast and robust, they can learn and adapt to data. and finally the ability to generalize. But the difficulty with using negative electronic devices is that they always produce results even if the input data is not suitable, and once a neural network has been trained to perform certain tasks, for example, it is difficult to evaluate other tasks. has to retrain neural networks (Ibrahim, 2002).

Artificial neural networks are used in electronics because artificial neural networks work based on natural thinking and can be input into neural network equipment to obtain solutions by making biological assessments of real-world problems in energy production, distribution and distribution. The actual values of the parameters cannot be determined taking into account the limitations of actual transmission and distribution. For example, the value of inductance, capacitance and resistance in the transmission line can be calculated by the neural network, which includes many factors such as environmental, imbalance and other common problems (Momoh-James, 2000).

Resistance, capacitance and inductance value of the transmission line can also be given as input and the combination of no capacitance can be obtained. This can reduce the impact of skin and proximity to something. Artificial neural networks are especially useful for problems that require fast results, such as real-time tasks. This is because they can produce results quickly after providing input (Ibrahim, 2002).

Artificial neural networks are applied to the generator to ensure that energy problems relate to specific nonlinear functions and also to ensure that time is included.

2.2.2 Electrical Systems

According to Gupta (2018), electrical power is the combination of components and equipment designed to generate, transmit, distribute and use electrical energy. Similarly, Sen (2014) defines electricity as a set of energy and energy sources that form a unified system in which electrical energy can be produced, distributed and used. The power system can generally be defined as the system that includes the production, transmission, distribution and use of electrical energy.

Charles (2007) defines the electrical system as a combination of components designed to produce, transmit and distribute electrical energy. Similarly, according to Allan (2013), a power system is an arrangement of electrical equipment and networks designed to perform specific tasks such as energy production, distribution and management. Electrical engineering includes the design, installation and maintenance of electrical equipment, as well as the production, distribution and reliability of electrical equipment where electricity is continuous (Nelson, 2013).

A power grid is a network of electrical equipment used to supply, transmit and use electricity. Electrical engineering is a branch of electrical engineering that deals with the design, transmission, distribution and use of electricity and electrical equipment connected to systems such as generators, motors and transformers (Pasupathi and Nishanth, 2003).

As stated by Garnier (2013), a power system is a network of electrical equipment used to supply, transmit and use electricity for homes and businesses in the renewable energy sector. The power grid can be divided into various parts such as generators, transmission systems, load stations and distribution systems. The electrical system is the combination of electrical equipment, electrical equipment, and equipment that provides the safe, efficient, and productive use of electricity for many applications, from simple household products to complex commercial products (Cooper, 2021). It consists of all the elements necessary for electrical distribution, including overhead and ground lines, poles, transformers, and other equipment (Collins Dictionary, 2023). Energy systems include infrastructure and equipment responsible for the production, storage, distribution and use of electricity (Smith, 2006). According to Johnson (2013), an electronic system refers to the combination of electrical and electronic components that facilitate the flow and control of electricity in an application or environment. Additionally, the electrical system is an arrangement of electrical conductors, switches, and devices that can generate, transmit, and use electricity for various purposes (Lee, 1999). Additionally, electrical systems include electrical equipment such as generators, electrical equipment, electrical equipment, and loads that work together to deliver electricity to end users (Brown, 2012).

Equally, according to Anderson, (2015) electrical systems involve the integration of electrical equipment and devices to achieve the efficient and safe utilization of electrical power for residential, commercial, or industrial applications. Clark, (2003) further explained that electrical systems are networks of electrical conductors and devices that enable the conversion and transmission of electrical energy to fulfill specific requirements within a given system.

As stated by Taylor, (2011) electrical systems encompass the design, installation, and maintenance of electrical infrastructure, including power generation, transmission lines, electrical panels, and circuits, for reliable and efficient power delivery. Electrical systems involve the integration of electrical components, control systems, and wiring to facilitate the reliable and effective operation of electrical equipment and machinery (Martinez, 2008).

Again, electrical systems refer to the interconnected electrical devices, conductors, and protective measures employed to ensure the safe and efficient utilization of electrical energy in various applications (Ramirez, 2019). Electrical systems comprise the organized arrangement of electrical components and wiring that enable the control, distribution, and utilization of electricity within a specific environment or system (Turner, 2007).

Moreover, electrical systems are the combination of electrical power sources, conductors, switches, and loads that collectively provide electricity for lighting, heating, communication, and other electrical requirements (Walker, 2014). Electrical systems involve the interconnection of electrical devices, protection systems, and wiring to ensure the efficient and reliable delivery of electrical power in residential, commercial, or industrial settings (Harris, 2005). Electrical systems encompass the integration of electrical equipment, wiring, and control mechanisms to enable the transformation and distribution of electrical energy for specific applications or purposes (Cooper, 2010).

Electrical systems refer to the arrangement of electrical components, circuits, and control systems that facilitate the conversion, distribution, and utilization of electrical power in a coordinated manner (Reed, 2017). Electrical systems comprise the design, installation, and operation of electrical infrastructure, including power generation, transmission, and distribution, to meet the electricity demands of various sectors. (Mitchell, 2002). Electrical systems are the collection of interconnected electrical devices, conductors, and control systems that enable the safe and reliable transfer and utilization of electrical energy within a designated system (Ward, 2016).

Electrical systems involve the integration of electrical components, circuits, and control mechanisms to facilitate the efficient generation, transmission, and utilization of electrical power for residential, commercial, or industrial purposes (Peterson, 2009). Thus, for the purpose of this study the definition of Gupta, (2018) was adopted as the best definition of electrical systems for the study.

2.2.3 Conceptual Framework

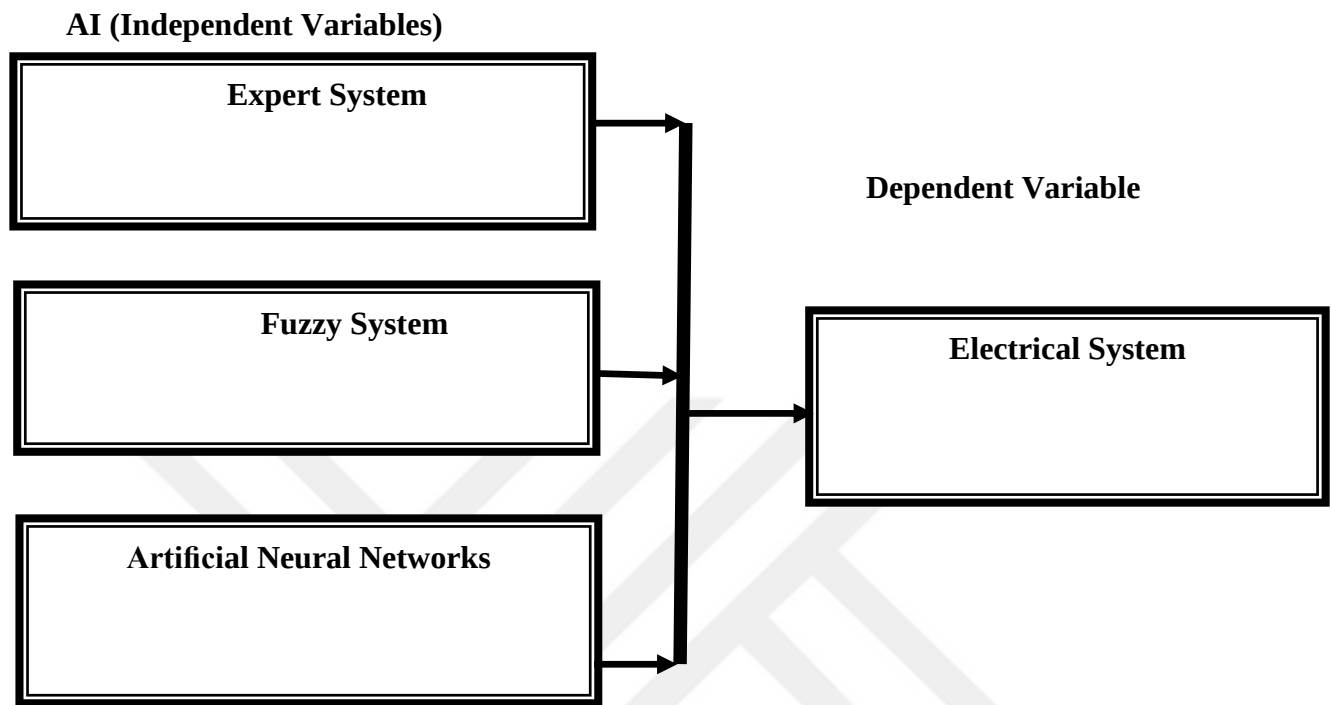


Figure: 4 Conceptual Framework

Source: Researcher Conceptualisation, (2023).

Figure 2.4 above shows the relationship between AI and electricity. There are two differences; difference between difference and difference. The independent variable is artificial intelligence (AI), divided into experts, fuzzy machines, and neural networks. The difference is voltage. The relationship between artificial intelligence and electronic systems is developing further.

Artificial Intelligence (AI) plays an important role in improving electricity by making it more efficient, making processes more efficient and providing better maintenance. Artificial Intelligence systems help improve the delivery and management of energy projects to meet customer needs. They make effective application strategies and energy management in smart projects (Ashfaq et al., 2017). Artificial Intelligence technologies such as machine learning help detect and diagnose errors or anomalies in electronic systems. They can analyze big data and identify patterns to predict failure, enabling effective monitoring and timely intervention (Muslea et al., 2005).

Fuzzy logic system outputs the failure mode based on fault detection. Expert systems (ES) and neural networks (ANN) help optimize production lines. Environmental sensors provide feedback to system experts and produce outputs based on critical measurements. Environmental sensors enable the ANN to identify critical parameters outside the specified range. The ANN training algorithm tests the neural network and identifies the bias for each hidden layer (Nath, 2014).

AI systems can predict and prevent equipment failure by continuously monitoring and analyzing sensor data from electrical systems. This enables the implementation of predictive maintenance strategies, reducing downtime and maintenance costs (Li et al., 2018). AI systems assist in optimizing energy consumption by analyzing historical usage patterns, weather data, and occupancy information. They provide insights for controlling and reducing energy waste, thus improving overall energy efficiency (Pandey et al., 2020).

2.3 Theoretical Review

There are various theories and concepts that have emerged over the years in the field of Artificial Intelligence (AI). It's important to note that these theories often intersect and combine in various AI applications. The field of AI is highly diverse and ongoing research and advancements continually expand our understanding and capabilities in creating intelligent machines. Here are a few prominent theories along with their respective authors.

2.3.1. Turing Test

Turing test was created by Alan Turing to test the ability of machines to exhibit intelligent behavior indistinguishable from humans. The spin test shows that a machine can be considered intelligent if it can exhibit behavior that is no different from a human during conversation. It is a concept recognized in the field of artificial intelligence and influences the development of language processing and chatbot technology.

The essence of the Turing Test consists of a decision maker talking to two entities, a human and a machine. The judge does not know which part is human and which part is machine. A machine is said to have passed the Turing test if it can convince a judge that it is human. This test is designed to test a machine's ability to understand, reason, and generate relationships, meaningful content, and human-like responses in natural language. Machines will exhibit an overall level of

intelligence that surpasses human intelligence. It focuses on the ability of machines to simulate human behavior, such as in speech. The Turing Test has become a standard for cognitive scientists and has fueled debates about the nature of intelligence, the limits of a machine's abilities, and the potential construction of machines with human intelligence. Although no machine has so far passed the Turing test, it remains an important concept in the field of artificial intelligence.

2.3.2. Symbolic AI

It was developed by John McCarthy, who coined the term "artificial intelligence" and developed the AI programming language LISP. This approach, also known as classical AI or Good Old-Fashioned AI (GOFAI), focuses on the manipulation of symbols and logical reasoning. It involves the use of formal rules, symbols, and logic to manipulate and process information. Symbolic AI relies heavily on expert systems, which are knowledge-based systems designed to mimic human expertise in a specific domain.

Symbolic AI, also known as classical AI or rule-based AI, is an approach to artificial intelligence that focuses on using symbols, logic, and knowledge representation to model and simulate human intelligence. It aims to solve problems by manipulating symbols and applying logical rules to them. In symbolic AI, knowledge is typically represented using symbols and formal logic, such as rules, facts, and relationships. These symbols can be structured in various ways, including semantic networks, frames, or predicate logic. The rules and logical operations define how the symbols can be combined, transformed, and reasoned about to derive new knowledge or make inferences.

Symbolic AI systems rely on explicit programming and predefined rules to process information and make decisions. They often involve a domain expert or a knowledge engineer who designs and encodes the knowledge into the system. The knowledge is typically represented in the form of if-then rules or logical statements that guide the system's behavior. One of the strengths of symbolic AI is its ability to handle complex reasoning and logic-based tasks. It excels in domains where explicit rules and logical deductions are crucial, such as expert systems, theorem proving, and knowledge-based systems.

However, symbolic AI also faces limitations. It struggles with dealing with uncertain or incomplete information, as it heavily relies on explicit knowledge representations. Symbolic AI systems can be brittle and inflexible, as they may not handle unexpected or novel situations well. Additionally, the process of acquiring and encoding expert knowledge can be time-consuming and resource-intensive. In recent years, symbolic AI has been complemented and sometimes integrated with other AI approaches, such as machine learning and neural networks, to overcome some of its limitations and create more robust and flexible AI systems.

2.3.3. Connectionism

This theory is related to the work of Warren McCulloch and Walter Pitts. Networking, also known as neural networks or parallel distributed processing (PDP), is an artificial intelligence (AI) method inspired by the structure and function of the human brain. It focuses on building computational models that contain interconnected circuits, or neurons, that work together to process information.

Connectionism, or neural network theory, describes the concept of intelligence resulting from the connection of simple functions called neurons or nodes. Connectionism, or neural networks, is a branch of artificial intelligence that derives from the structure and function of the human brain. It introduces the concept of learning through the interaction of nodes (false neurons) that mimic the behavior of the brain. Neural networks are trained on large amounts of data using mechanisms such as regression to adjust connections between nodes so they can learn patterns, recognize objects, and make predictions.

In the connectionist model, intelligence is not programmed or represented by symbols; It is the result of the connection and interaction structure between neurons. These connections are usually represented by a heavy link and allow data to flow and be processed within the same network. The principle behind the connection is that cognitive processes can be understood as the result of simple calculations working together in a distributed system. By adjusting the strength of connections between neurons (usually through learning), connection patterns can be learned from examples and their behavior adjusted over time. Captures non-linear relationships and the complexity of real-world problems. Efficient connectivity models of knowledge structure, task classification, and learning from big data. They are successful in many areas such as visual and

verbal recognition, language processing skills, modeling skills. a framework that allows for the wisdom that can emerge from distribution.

2.3.4. Evolutionary Computation

The theory was proposed in the book *Evolution in Natural and Artificial Systems* by John Holland, who contributed to the theory's development. Evolutionary calculations are inspired by the principles of biological evolution. It involves the use of evolutionary algorithms, genetic algorithms and genetic programming to solve complex problems. Evolutionary computation takes ideas from theories of biological evolution to solve complex problems. Genetic algorithms include methods such as genetic programming and evolutionary strategies. These machines simulate the process of natural selection by creating a population of candidate solutions, using genetic operators (mutation, crossover) and measuring their fitness. The algorithm converges to the optimal or near-optimal solution through iteration. It is a subfield of artificial intelligence that uses computational algorithms to simulate natural selection and genetic modification processes to solve complex problems. Evolutionary computation essentially involves generating a population of candidate solutions, usually represented by individuals or “chromosomes.” Each individual in the population has criteria or limitations that define its characteristics. These attributes can be encoded as phone numbers or other data structures. The power function determines how well each individual fits the problem and forms the basis of selection. Healthier individuals will be selected for reproduction, demonstrating the natural selection of many organisms in biology. Crossing over involves combining traits from both parents to produce new offspring, while mutation refers to small changes in behavior. These projects highlight genetic diversity and explore new areas of problem solving. New offspring are added to the population by replacing unhealthy individuals through a process called transgeneration. The process of selection, breeding and adaptation continues across generations, allowing populations to evolve towards better solutions. Performance gets better over time. Using the principles of genetic variation and selection, these algorithms can solve optimization problems, create central connections, change strategies, and solve many problems in the world. Evolutionary computing is a method that can be used in optimization, machine learning, robotics and many other fields. Its ability to harness the power of evolution and adaptability makes it an important tool in intelligence.

2.3.5. Bayesian Networks

Developed by Judea Pearl, Bayesian networks are graphical models that use probability to represent information and uncertainty. They are used to establish social connections and make predictions based on evidence and prior knowledge. Bayesian networks are graphical probabilistic models that use acyclic graphs to represent relationships between variables. They use the principles of Bayesian probability theory to reason under uncertainty. Bayesian networks allow them to make useful predictions, diagnoses, and control for missing data by using probability distributions to change beliefs about variables based on observed evidence.

2.3.6. Reinforcement Learning

It was created by Richard Bellman, who is considered one of the founders of RL for his contributions to good works. or punishment to learn to judge. Reinforcement learning (RL) is an artificial intelligence method in which workers learn to interact with their environment and maximize productivity. Agents explore the environment through trial and error, giving and receiving feedback in the form of reward or punishment. Reinforcement learning uses techniques such as Markov decision processes, value functions, and gradient rules to learn effective strategies for decision making and control in the environment. The idea of how to make decisions and act in an environment to maximize results. It is inspired by the way humans and animals learn through trial and error. In supporting learning, the agent interacts with the environment, observes its current state, and selects the appropriate course of action. After performing an action, the agent receives feedback from the environment in the form of a reward indicating the desirability of the action in that situation. The agent's goal is to learn the policy that will maximize profits over time. These algorithms update the agent's knowledge based on observed results and adjust the decision-making process accordingly. By repeatedly interacting with the environment, the agent discovers different behaviors and learns which behaviors will be more beneficial and which behaviors should be avoided. Research-marketing is an important part of promoting learning; because the agent must strike a balance between trying new things and making the best decisions using the information he currently has. Robots, recommendation systems and autonomous driving. It enables employees to learn difficult behaviors and make decisions in a dynamic and uncertain environment. Reinforcement learning enables one to

achieve a high level of self-control and flexibility by improving the performance of cognitive skills through trial and error.

2.4 Review of Empirical Literature

Youssef et al. (2021) conducted a study to show that the important technology used by artificial intelligence in electronic systems cannot keep up with all working and delivery situations of traditional methods. There is also a brief description for each machine mentioned, showing the specific purpose of the electrical power. Additionally, this system increases energy efficiency and productivity by controlling electricity, safety, energy consumption and load frequency. It also enables network management such as location, size and management of equipment and devices. Provides support for power system automation, recovery, diagnostics, management and cybersecurity. It is necessary to determine the intellectual property required for the preparation, monitoring and control of electrical systems.

Samin (2018) examined the applications of artificial intelligence in power engineering. Artificial intelligence (AI) tools are fast, powerful and flexible and can overcome the lack of solutions to many energy challenges. In this study, the use of mechanical engineering technology to solve two important problems in the electrical power system was examined. The first topic is Static Security Evaluation (SSE). The purpose of SSE is to determine the situation in electricity planning and operation. Traditional computational solutions are time-consuming and computationally expensive and are not suitable for online applications. SSE can be viewed as a binary distribution, polydistribution, or inverse problem. In this work, various support vector machines are combined with various computational algorithms to solve SSE, including particle swarm optimization (PSO), differential evolution, continuous field ant colony optimization, and correlation search strategies. Additionally, vector regression is supported by modified PSO and modified inertia weights are proposed to solve SSE. Moreover, the accuracy of the distribution, the training speed, and the final cost of using the power supply depend on the selection strategy. This article uses a multi-objective particle swarm optimization algorithm to solve this problem. It is also planned to conduct various types of surveys to obtain final exam results.

Singh and Wang (2008) examined the role of artificial intelligence in assessing the reliability of the US electric power system. Reliability analysis partly involves examining the state space for

states that represent the system's conditions of interest; typically the failure of the system or offering to meet the requirements. This essentially means looking for good situations to check and then using the machine to evaluate the situations. Traditionally, reliability testing has been based on random enrollment or precision sampling or Monte Carlo sampling. Recently, skill-based skills have been studied as an alternative to Monte Carlo in the research process, as well as situation assessment methods combined with the Monte Carlo method. It also provides some practical examples of reliability analysis of hybrid power systems that include generators and other electronic components.

Pasupathi and Nishanth (2003) conducted a study to examine intelligence in the Indian energy sector. Continuous and reliable electricity is needed to function in modern and advanced life. By the early to mid-1980s, most efforts in energy analysis moved away from mathematical modeling methods from science studies, controlled thinking, and numerical analysis for less rigid and less tedious intelligence techniques. (Artificial intelligence). Artificial intelligence technology is used in electrical engineering for management, planning, dispatch, forecasting, etc. It is widely used to solve different problems. This technology can solve complex tasks faced by applications in today's large power systems that are increasingly connected to meet growing demand. The use of this technology has been successful in many areas of energy engineering.

2.5 Research Gap

From the empirical literature and theoretical literature above, the study therefore addresses gaps in the following aspect.

Relating to the conceptual gap, there are limited researches on the impact of artificial intelligence on electrical systems in Buea Cameroon. That is despite the increasing importance of artificial intelligence in enhancing electrical systems, there still exist few studies in relation to artificial intelligence especially in Buea Cameroon. This study was conducted in Buea Cameroon to address this gap in the literature.

Also, despite numerous studies conducted on artificial intelligence on electrical systems, there is a deviation in the paths, variables and methodologies applied leading to conflicting results and causations; hence the need for the current research to expand on the body of knowledge. The studies reviewed used different techniques of artificial intelligence but this study intend to focus

on techniques such as expert system, fuzzy system and artificial neural networks which most studies have not exploit to address the conceptual gap.



CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

A cross sectional research design will be used for this study to examine the impact of AI on electrical systems in Buea-Cameroon. Successfully the design was adopted because the researcher will be collecting data from the sample at a particular point in time using different variables.

3.2 Area of the study

Eneo is Cameroon's largest energy company. The company is part of the state, 51% of the capital belongs to Actis, 5% to Eneo employees and 44% to the Cameroonian government. In terms of electricity generation, Eneo's electricity generation capacity is 968 MW. Electricity production consists of 39 power plants, 13 of which are grid power plants and 26 are regional thermal power plants. Eneo produces 74% of its electricity from hydroelectricity. There are 24 stations in the transmission network, including 1,944.29 kilometers of high voltage line, 15,081.48 kilometers of medium voltage line and 15,209.25 kilometers of low voltage line.

ENEО has multiple offices and power stations covering the major cities in Cameroon, with day to day paper interactions with customers, internal departments and external entities. In the legacy system, paperwork was handled manually and stored in multiple warehouses with manual input and basic digital archiving. The main pain areas for the customer was the risk of losing data and the lack of a proper methodology to index documents so any information can be retrieved in seconds.

For an entity serving the whole country of Cameroon, knowledge is power and the legacy system was not allowing the full monetization of content and information. ENEО Cameroon partnered with Infas Middle East, an authorized Fotopia reseller to create a complete digital transformation plan that involved creating a document management system, content automation hierarchy, content workflows and a customizable search engine for their ECM. Replacing the legacy manual document handling with a complete enterprise content management system that included Microsoft SharePoint, FotoCapture, FotoGnize, FotoView, and FotoFind ensured that ENEО

employees can capture information easily, collaborate on documents, search and find any content in seconds and have a safe and secured archiving system in place under Microsoft SharePoint.

3.3 Population of the Study

The target population for this study comprises of customers of ENEO in Buea Cameroon. This constitutes household resident in Buea Cameroon. The population of the study constitutes of 2000 household utilizing electrical systems. This includes both male and female customers selected with no gender bias and educational qualification.

3.4 Sampling procedure and Sample Size

3.4.1 Sampling procedures

. Purposive sampling methods was used in this study. Purposive sampling is about achieving a specific goal in the mind of the researcher. Researchers use their own judgment in selecting those members of the population who are most likely to receive accurate information. Therefore, researchers deliberately select a particular population based on their knowledge. The content of the selected sample forms the basis of the researcher's decision. When selecting a sample, researchers will focus on subjects who are easy, approachable, accessible, and willing to participate. Therefore, the researcher will select participants who have good expectations about the information needed for the study. Purposive sampling is best for this study because it allows the researcher to obtain rich information from the subjects. When selecting a sample, researchers will focus on subjects who are easy, approachable, accessible, and willing to participate.

3.4.2 Sampling size

The sample size of the study is determined from the population. The study made used of a sample of 333 households customers of ENEO Buea. This is determined using the Yamane formula as estimated below.

$$\frac{N}{1+N(e^2)}$$

Where:

N = the total population size

e = the level of precision

For this study the level of precision is considered at 5%.

$$\begin{aligned}\text{Thus, sample size (n)} &= \frac{2000}{1+2000(0.05)^2} \\ n &= 333\end{aligned}$$

3.5 Instruments

3.5.1 Instrument of Data Collection

The tool used to collect research data is a survey. Questionnaires were used due to their ease of use and reliability. The questions used in this study are divided into three parts: A, B and C (experts, fuzzy machines and neural networks). Section "C" of our survey contains questions regarding different parts (electrical system). Using five-point Likert scale statements allows the researcher to clearly analyze the data by comparing and showing how the respondents felt about the content of the survey. Coding techniques were used to transform the data from qualitative to quantitative data. Coding is used to transform data in a way that is meaningful and easy to analyze. For this purpose, numerical values were assigned to the response on a five-point Likert scale; for example, 1 = Disagree, 2 = Disagree, 3 = Disagree, 4 = Agree, 5 = Strongly Agree. This value is used to enter the responses into SPSS software for analysis.

3.5.2 Instrument of data analysis

The data is analyzed using descriptive and inferential analysis.

Descriptive Analysis

Descriptive analysis is used in other to summarize data points in a constructive way. In this study, the descriptive tools used are frequency distribution tables, percentages and graphical description (charts).

Inferential Analysis

This study adopts the multiple linear regression analysis. Regression technique is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables. The impact of artificial intelligence on electrical system in Buea

Cameroon is analyze using the multiple regression analysis and the results is validated using the ordinary least square (OLS) technique to derive the estimates.

Model Specification

The model shows the relationship between independence and academic achievement. Independent variables are input into experts, fuzzy systems, neural networks and different types of electronic devices. The model is shown below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon \dots\dots\dots (1)$$

Y = represent Electrical System

β_0 stands for the Constant Term

X_1 in the equation represent Expert System,

X_2 represent Fuzzy System,

X_3 in the equation stand for Artificial Neutral Networks,

ϵ in the model stands Error Term

$\beta_1, \beta_2, \beta_3$ are the coefficient of the explanatory variables to be estimated

3.5.3 Variables and Measurement

Independent Variables

Expert System

It is measured by the system ability to learn or adapt, ease to make decision, processing method, system modification and ability of the system to handle complex data and information, solving issues and judgment.

Fuzzy System

It is measured by the system ability to utilizes software or hardware mode, standardize and formalize approach, ability of the system to perform as humans, ease to connect, diagnosis, security assessment and power planning and control and the system degrees of truth.

Artificial Neural Networks

It is measured by the speed processing of the system, knowledge of the system model, ability of the system to handle situations of incomplete data and information and are fault tolerant and quickly generate results.

Electrical Systems

It is measured by the system ability to generate, transmit, distribute and utilize electrical energy, ensuring the reliable and continuous supply of electricity, control systems and wiring and lighting, heating, communication and other electrical requirements.

3.6 Data Collection

Primary data is collected in this study with the used of the questionnaire. This is because this primary data was considered to be more consistent with the research problem and objectives since it was collected first hand with the focus of meeting the objectives of the study. The researcher issued to the respondents in person the questionnaires to fill in which the questionnaires are expected to be filled and returned immediately after completely filling it by the respondents due to the fact that being customers, the researcher will find it difficult to locate them after giving the questionnaires.

3.7 Data Analysis Procedure

When the data was received, missing or unfilled data in the survey was checked and corrected. Only correct spellings was used. After cleaning and correcting, coding was done in the analysis software. The statistical software used for analysis is SPSS (Statistical Analysis Program) because it is easy to use and the findings are easy to communicate. Descriptive statistics in this study help explain, present and summarize the many data collected in context. Additionally, the relationship between each freedom and success is shown. Multiple regression was used to establish the relationship between corporate value and customer loyalty in Buea Telecom Company. The process ends with analyzing and finalizing the research results.

3.8 Ethical Consideration

Ethical issues were taken in consideration in the process of carrying out the research. Amongst them is the confidentiality of information provided will be ensured as participant names were not

required. Also Participant consent was equally sort before data collection. The use of offensive discriminatory or other unacceptable language was avoided in the information of the questionnaire which went along way to produce consistence and realistic results for the research.



CHAPTER FOUR

PRESENTATION OF FINDINGS

4.0 Introduction

This chapter focuses on the data collected during the study to assess the impact of Cameroon's electrical knowledge. The findings are presented in tables and graphs with appropriate explanations. This section contains the participant's response indicating how many participants participated in the study. Responses to these questions were calculated and then presented as percentages of words and images.

Table 1: Response Rate of Questionnaire

Number of Questionnaires	Total Number	Percentage
Questionnaires Given Out	333	100%
Questionnaires Returned	329	98.8%
Questionnaires Not Received	04	1.2%

Source: Field Survey by Author, (2022).

Table 4.1 shows that 329 of the 333 surveys distributed were returned. Mugenda and Mugenda (2003) found that the response to a survey was reasonable if the response rate was seventy-five percent (75%) or higher. On this basis, the survey was analyzed.

4.1 Descriptive Statistics for Demographic Characteristics of Respondents

4.1.1 Gender Distribution of the Respondents

From the data collected from the respondents, a total of 252 respondents happen to be male making 76.6% and 77 respondents are females making 23.4% of the total number of respondents. This is an indication that majority of the respondents were males. The reason why there were more males than females is because the men are the head of the home and they pay a lot of bills.

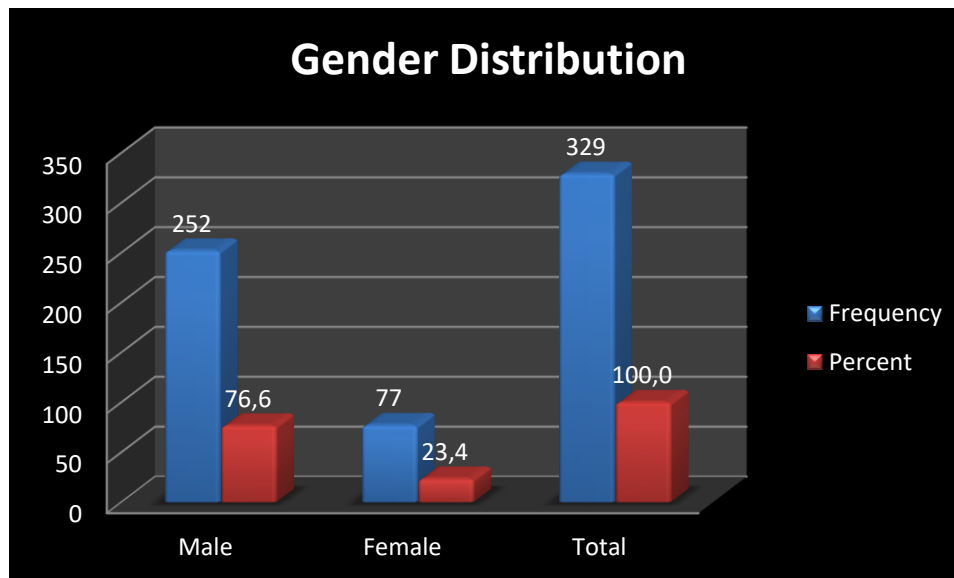
Table 2: Frequency Distribution of Respondents According to Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Male	252	76.6	76.6	76.6
Female	77	23.4	23.4	100.0
Total	329	100.0	100.0	

Source: Computed from SPSS 21.0

The frequencies and percentages of the above table are summarized in figure 1 below on a bar chart.

Figure 5: Frequency Distribution of Respondents According to Gender



Source: Computed from Excel, (2023)

4.1.2 Age Distribution of Respondents

The distribution of respondents according to their age groups shows a high participation of respondents with a total of 34 respondents with the ages range below 20years making 10.3%, a total of 166 respondents between the ages 20-29years making 50.5%, a total of 32 respondents between the ages 30-39years making 9.7%, a total of 53 respondents falling between the ages of 40-49years making 16.1% of the total number of respondents and a total of 44 respondents falling between the ages of 50years and above making 13.4% of the total number of respondents. This shows that most of the respondents who participated in these studies fell between the age 20 to 29 and 40 to 49 years. This is shown in table 4.3 below.

	Frequency	Percent	Valid Percent	Cumulative Percent
Below 20years	34	10.3	10.3	10.3
Valid 20-29years	166	50.5	50.5	60.8
30-39years	32	9.7	9.7	70.5

40-49years	53	16.1	16.1	86.6
50years and above	44	13.4	13.4	100.0
Total	329	100.0	100.0	

Table 3: Age Distribution of Respondents

Source: Computed from SPSS 21.0

The age distribution of respondents' base on their ages is presented on a bar chart in figure 6 below.

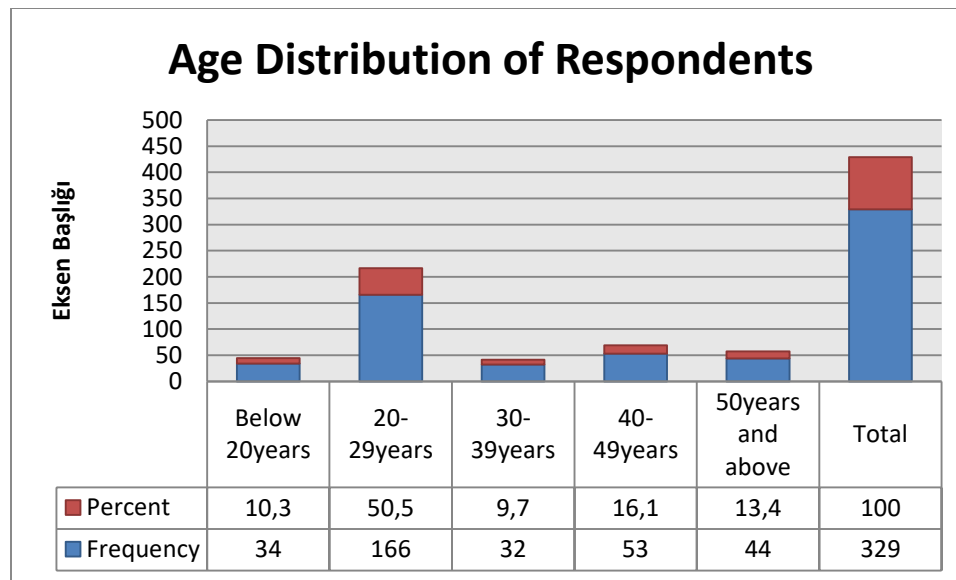


Figure 6: Age Distribution of RespondentsSource: Computed from Excel, (2023)

4.1.3 Distribution of Respondents by Level of Education

A total of 3 respondents happens to be First School Living Certificate (FSLC) making up 9% of the total of respondents. Again, a total of 66 respondents attained Ordinary Level (OL) making 20.1%. Still, a total number of 66 respondents attained Advance Level (AL), making 20.1%. Still, a total number of 133 respondents' attained B.Sc. making 40.4%. Moreover, a total number of 44 respondents' attained M.Sc. making 13.4% and a total of 17 respondents attained other certificates not mentioned in the study making 5.2%. This is presented in table 4.4 below.

	Frequency	Percent	Valid Percent	Cumulative Percent
FSLC	3	.9	.9	.9
Ordinary Level (OL)	66	20.1	20.1	21.0
Advance Level (AL)	66	20.1	20.1	41.0
Valid B.Sc.	133	40.4	40.4	81.5
M.Sc.	44	13.4	13.4	94.8
Others	17	5.2	5.2	100.0
Total	329	100.0	100.0	

Table 4: Educational Level Distribution of Respondents

Source: Computed from SPSS 21.0

The age distribution of respondents' base on their ages is presented on a bar chart in figure 7 below.

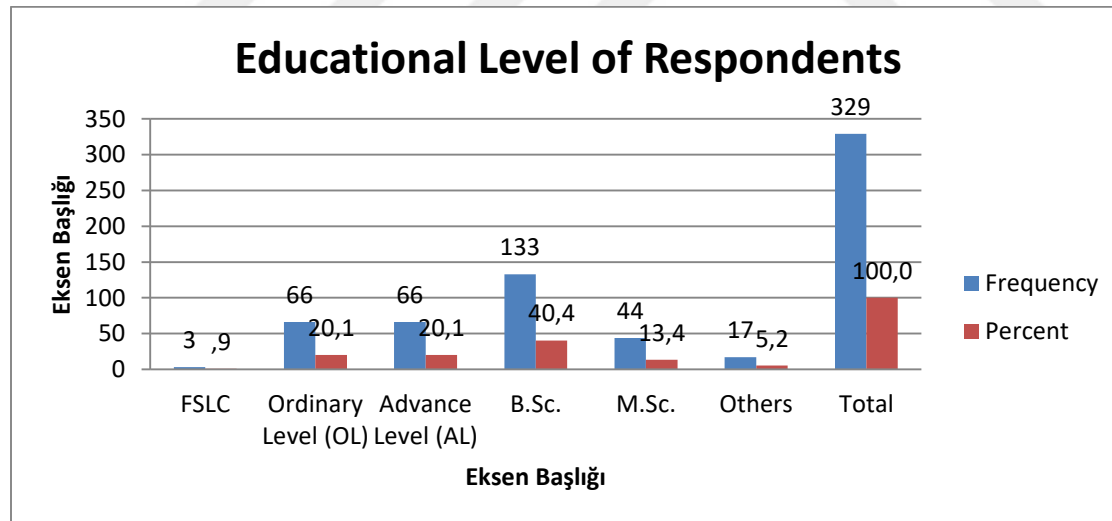


Figure 7: Educational Level of Respondents

Source: Computed from Excel, (2023)

4.1.4 Distribution of respondents by marital status

Findings regarding marital status of respondents reveal a total of 55 respondents who are single making 16.7%, and a total of 274 respondents who are married making 83.3%. More married persons therefore participated in the study than singles. This is shown in table 4.5 below.

Table 5: Marital Status Distribution of Respondent

	Frequency	Percent	Valid Percent	Cumulative Percent
Single	55	16.7	16.7	16.7
Married	274	83.3	83.3	100.0
Total	329	100.0	100.0	

Source: Computed from SPSS 21.0

The age distribution of respondents' base on their ages is presented on a bar chart in figure 8 below.

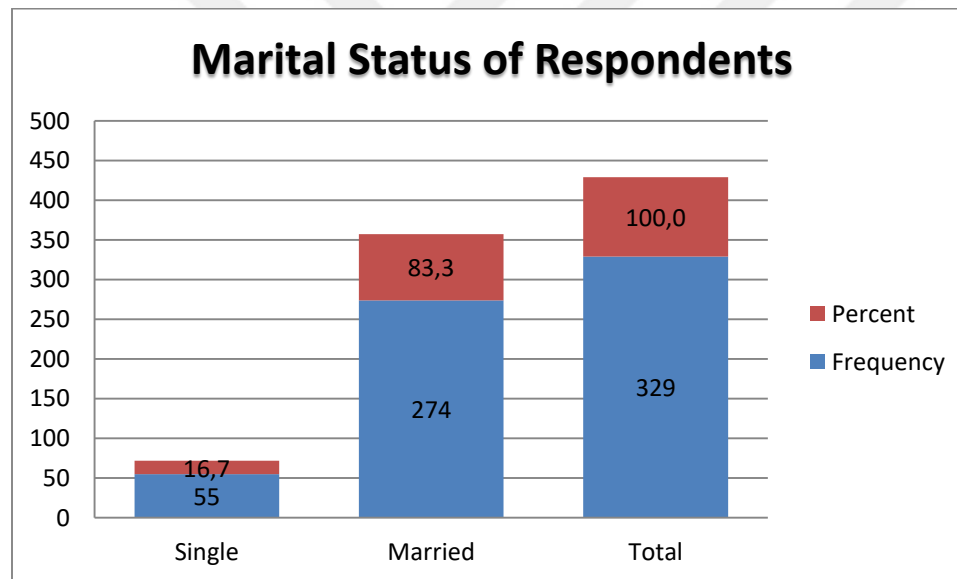


Figure 8: Marital Status Distribution of Respondents

Source: Computed from Excel, (2023)

4.1.5 Distribution of Respondents by Electrical System in their Household

Findings reveal all the respondents accepted that they all use electrical system in your household. This is shown in table 6 below.

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	329	100.0	100.0	100.0

Table 6: Marital Status Distribution of Respondent

Source: Computed from SPSS 21.0

4.2 Summary of Descriptive Statistics of Variables

	N	Minimum	Maximum	Mean	Std. Deviation
Expert System	329	1.00	3.17	3.40	1.38
Fuzzy System	329	1.00	3.67	3.01	1.57
Artificial Neutral Network	329	1.00	3.67	3.670	1.43
Valid N (listwise)	329				

Table 7: Summary of Descriptive Statistics of Variables

Source: Computed from SPSS 21.0

Table 6 shows that the sum mean for all the Artificial Intelligence (AI) variables ranged from 3.17 for expert system, 3.67 for fuzzy system, and 3.29 for artificial neutral network. With respect Artificial Intelligence (AI) variables, all the three variables recorded means above 3.0 meaning that above half of the respondents confirmed that Artificial Intelligence (AI) apparatus are being used in their homes. By implication, inhabitants in Buea could attest of the high use of Artificial Intelligence (AI) on electrical systems in Buea Cameroon. On the other hand, the standard deviation values ranged from 1.38, 1.57 to 1.43; indicative of less variation in responses. Besides, the minimum values were all 1 and maximum.

4.3 Inferential Analysis

The inferential analysis presents the result gotten from our multiple regression analysis. However, before we establish the result, we shall first ascertain the reliability of the construct tested using the Cronbach's Alpha.

4.3.1 Test of Reliability of Constructs

Cronbach's Alpha	N of Items
.874	24

Table 8: Reliability Statistics

Source: Computerised in SPSS, (2023)

4.3.2 Test of Reliability of Individual Constructs

Testing for the reliability of constructs in the study, the cronbach alpha method mentioned in the methodology is employed. This was in order to determine the internal consistency of the constructs. This analysis is presented on the subsequent table.

Variables		Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Artificial Intelligence (AI)	Expert System	0.705	0.776	6
	Fuzzy System	0.779	0.798	6
	Artificial Neural Network	0.883	0.880	6

Table 9: Test of Reliability of Individual Constructs

Source: Computerised in SPSS, (2023)

Cronbach's alpha reliability test was used to measure internal consistency. Reliability testing of the scale involves checking whether the items have factor loadings of at least .70; this indicates that items share more variance with the construct rather than forced variance experience and are considered reliable (Carmines et al., 1994). As can be seen from the table above, the difference between different types of artificial intelligence (AI) such as experts, fuzzy machines, and broken radios are 0.705, 0.779, and 0.883 respectively, which means they share a lot of variance. with construction as the subject. Therefore, expert systems, fuzzy systems and neural networks are considered reliable, as suggested by Nunnally and Bernstein (1994).

4.3.3 Multiple Regression Analysis

To answer specific research questions, multiple linear regressions were conducted using the results found in the sample guide, analysis of variance (ANOVA), and estimated coefficients.

4.3.3 Regression model summary analysis

The summary of the regression model shows the significance of the correlation coefficient (R), coefficient of determination (R Squared), correction coefficient, and estimated standard error. The value of the global correlation coefficient was found to be 0.590, which explains that different prediction methods (artificial neural network, fuzzy system, expert system) have a moderate correlation with different prediction methods (electrical system). The coefficient of determination (adjusted R-squared) indicates a value of 0.342; This explains that 34.2% of changes in electricity (dependent variable) can be predicted by equipment negative energy, fuzzy systems, experts (independent variables). Therefore, 65.8% of the variation in electricity production of Buea in Cameroon can be predicted from other factors not considered in this study. This is shown in Table 4.10 below.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.590 ^a	.348	.342	.53525

a. Predictors: (Constant), Artificial Neural Network, Fuzzy System, Expert System

Table 10: Model summary

Source: Computed from SPSS 21.0

4.3.4 Analysis of variance

The ANOVA table brings out the sum of explained squares, residual sum of squares and the total sum of squares as well as the degree of freedom, mean square, Fischer values and global significance level of the model. The general significance level indicated on the table is 0.00 with a high F value of F (57.772) which shows that the model is generally significant. Therefore, Artificial Intelligence (AI) System are significant enough to determine the performance of electrical systems in Buea-Cameroon ($p = 0.000$). This is indicated in table 4.11 below.

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	49.654	3	16.551	57.772	.000 ^b
	Residual	93.111	325	.286		
	Total	142.765	328			

a. Dependent Variable: Electrical Systems

b. Predictors: (Constant), Artificial Neural Network, Fuzzy System, Expert System

Table 11: Analysis of variance. Source: Computed from SPSS 21.0

4.3.5 Analysis of regression coefficients

Table 12: Analysis of regression coefficients

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.082	.142		.576	.565
	Expert System	.706	.129	.410	5.481	.000
	Fuzzy System	.254	.063	.222	4.037	.000
	Artificial Neural Network	.070	.098	.046	.712	.477

a. Dependent Variable: Electrical Systems

The coefficients table gives the estimated values for the parameters of the model as well as their individual significance levels with their t values. Findings reveal a constant value of $\beta_0 = 0.082$ and values of 0.706, 0.254, and 0.070 for β_1 , β_2 , and β_3 respectively. This permits us to come out with the following estimated model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \dots\dots\dots (1)$$

$$Y = 0.082 + 0.706X_1 + 0.254X_2 + 0.070X_3$$

Y = represent Electrical System

B₀ stands for the Constant Term

X_1 in the equation represent Expert System,

X_2 represent Fuzzy System,

X_3 in the equation stand for Artificial Neural Networks



CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion of Result

This section presents the discussions of the results gotten from the multiple regression analysis in the previous chapter. These results are discussed as per the objectives of the study chronologically.

5.1.1 Discussion of Result According to Objective/Variable One (Expert Systems)

According to the multiple regression estimated table, a unit increase in the usage of expert systems in ENEO Cameroon and households in Buea Municipality will positively impact the electrical system by 0.706. This result indicates that the (AI) expert system put in place by ENEO Cameroon and households in Buea Municipality positively impact the electrical systems in Buea Cameroon by 70.66%. This positive impact could be accounted for the following reasons;

1. **Fault Detection and Diagnostics:** ENEO Cameroon and households use expert systems to analyze vast amounts of data collected from electrical systems to detect faults or abnormalities. They can interpret complex patterns and identify potential issues that may go unnoticed by human operators. This allows for early detection and preventive maintenance, reducing downtime and improving reliability.
2. **Predictive Maintenance:** By continuously monitoring electrical system performance and analyzing historical data, expert systems can predict when components might fail or need maintenance. This helps companies optimize maintenance schedules and avoid unplanned downtime or disruptive breakdowns.
3. **Energy Efficiency:** ENEO Cameroon and households use expert systems to optimize energy usage by monitoring and controlling electrical loads in real-time. They can adjust devices and systems to minimize energy wastage and maximize efficiency based on variables like occupancy, weather conditions, and power demand.
4. **Load Balancing and Grid Stability:** AI-based expert systems can help balance electrical loads across the grid, ensuring optimal utilization of resources and preventing overloading. They can also assist in managing voltage levels, frequency control, and maintaining grid stability during fluctuations or extreme conditions.
5. **Improved System Design and Planning:** Expert systems can aid in the design and planning of electrical systems, taking into account factors such as load requirements, environmental

conditions, and safety standards. This helps engineers and planners optimize system performance, reduce costs, and enhance overall reliability.

6. Decision Support: Expert systems provide valuable insights and recommendations to human operators or decision-makers. By analyzing data and applying industry knowledge, they can suggest optimal decisions, such as equipment upgrades, system expansions, or implementing new technologies for better performance.

7. Enhanced Safety: AI-based expert systems can improve safety in electrical systems by continuously monitoring for potential hazards, such as short circuits or fire risks. They can activate protective measures automatically or issue real-time warnings to human operators, enabling prompt action to prevent accidents or damages.

Overall, the integration of expert systems and AI in ENEO Cameroon and households in electrical systems has brought about significant improvements in efficiency, reliability, safety, and cost-effectiveness in ENEO Cameroon. As these technologies continue to advance, we can expect even more transformative impacts in the future.

5.1.2 Discussion of Result According to Objective/Variable Two (Fuzzy System)

According to the multiple regression estimated table, a unit increase in the usage of fuzzy system within ENEO Cameroon and households in Buea Municipality will positively impact the electrical system by 0.254. This result indicates that The (AI) fuzzy system put in place by ENEO Cameroon and households in Buea Municipality positively impact the electrical systems in Buea Cameroon by 25.4%. This positive impact is could be accounted for the following reasons;

1. Control Systems: Fuzzy logic controllers have been widely applied to improve the control and optimization of electrical systems. Fuzzy controllers can handle non-linear and complex systems, making them suitable for a variety of applications such as power generation, transmission, and distribution. By employing fuzzy reasoning, these systems can effectively manage power flow, voltage regulation, and load balancing in electrical grids.

2. Fault Diagnosis: Fuzzy systems have been employed to diagnose faults and anomalies in electrical systems. By modelling uncertain and incomplete information, fuzzy inference systems can analyse sensor data and identify potential faults or abnormal behaviours in real-time. This

helps in predicting failures and allows for timely maintenance, minimizing downtime and improving the overall reliability of electrical systems.

3. Energy Management Systems: Fuzzy systems have been instrumental in enhancing energy management systems. They can incorporate data from various sources, including weather conditions, energy demand, and renewable energy availability, to optimize energy usage and distribution. Fuzzy systems can adaptively adjust energy resources and load allocations, maximizing energy efficiency and reducing costs.

4. Power Quality Improvement: Fuzzy systems have also been used to address the issue of power quality in electrical systems. By considering a range of parameters and factors, such as voltage fluctuations and harmonic distortions, fuzzy systems can automatically adjust control parameters to maintain high power quality. This helps to prevent power disruptions, equipment damage, and ensures the stability and reliability of electrical systems.

5. Smart Grid Applications: Fuzzy systems play a vital role in enabling smart grid capabilities. Smart grids require intelligent decision-making and management to handle the increased complexity of integrating renewable energy sources, energy storage, and demand response. Fuzzy systems provide the ability to analyse and interpret data from diverse sources, enabling efficient monitoring, control, and optimization of smart grid components and operations.

In conclusion, fuzzy systems setup in Cameroon have had a significant impact on electrical systems by improving control, fault diagnosis, energy management, power quality, and enabling smart grid applications. These AI-based approaches offer enhanced efficiency, reliability, and adaptability, contributing to the overall advancement of electrical systems.

5.1.3 Discussion of Result According to Objective/Variable Three (Artificial Neural Network)

According to the multiple regression estimated table, a unit increase in the usage of Artificial Neural Network (ANN) within ENEO Cameroon and households in Buea Municipality will positively impact the electrical system by 0.070. This result indicates that the (AI) Artificial Neural Network (ANN) put in place by ENEO Cameroon and households in Buea Municipality positively impact the electrical systems in Buea Cameroon 7%. This positive impact is could be accounted for the following reasons;

1. Fault Detection and Diagnosis: ENEO Cameroon and households can use ANNs for fault detection and diagnosis in electrical systems. By training an ANN model on large amounts of

data, it can learn to recognize patterns associated with faults. This enables early detection of potential failures or abnormal behaviour, allowing for timely maintenance or troubleshooting.

2. Load Forecasting and Management: ENEO Cameroon and households can use ANNs for load forecasting in electrical systems, helping utility companies predict electricity demand accurately. This enables more efficient load management, reduction of energy waste, and optimization of electricity generation and distribution.

3. Power System Control: ANNs can assist in controlling the power flow in electrical systems. By analyzing real-time data, ANNs can predict optimal control actions for voltage and power regulation, leading to improved efficiency and stability.

4. Energy Management Systems: ENEO Cameroon and households can apply ANNs to manage energy, which monitor and optimize energy consumption in buildings, factories, and power grids. ANNs can learn patterns of usage and make real-time decisions to optimize energy consumption and reduce costs.

5. Renewable Energy Integration: ENEO Cameroon and households can use ANNs to help integrate renewable energy sources, such as solar and wind power, into electrical grids more effectively. ANNs can predict renewable energy outputs based on historical data and weather forecasts, which assists in optimizing the grid's operation, reducing reliance on non-renewable sources, and promoting sustainability.

5.2 Conclusion

The impact of AI (expert systems, fuzzy systems, and artificial neural networks) on electrical systems has been significant. Therefore we can conclude that;

Expert systems have played a crucial role in diagnosing and solving complex electrical problems. By capturing expert knowledge and rule-based reasoning, expert systems can assist engineers and operators in making informed decisions and suggesting optimal solutions. This has led to improved fault detection, predictive maintenance, and overall system reliability in electrical systems.

Fuzzy systems, known for their ability to handle imprecise and uncertain data, have also made a positive impact. Electrical systems often deal with input values that are not crisp or well-defined. Fuzzy logic allows for a more flexible and robust approach to decision-making, enabling better control and optimization of electrical processes. Fuzzy systems have been successfully applied in areas such as voltage control, load forecasting, and power system stability analysis.

Artificial neural networks (ANNs) have revolutionized various aspects of electrical systems. ANNs are capable of learning complex patterns from data and making intelligent predictions. In power systems, ANNs have been used for load forecasting, fault diagnosis, and load flow analysis. They can help in improving system efficiency, reducing downtime, and enhancing overall system performance.

Overall, the integration of expert systems, fuzzy systems, and artificial neural networks has brought about significant advancements in electrical systems. These technologies have empowered engineers, operators, and researchers to tackle complex problems, improve system reliability, optimize operations, and enhance overall performance.

5.3 Recommendation

Based on the findings, Expert Systems, Fuzzy Systems, and Artificial Neural Networks have a significant impact on electrical systems in Cameroon. Therefore, the study has made the following recommendations:

1 .Expert Systems:

ENEO Cameroon and households should strengthen the implementation of expert systems so as to aid in fault diagnosis and troubleshooting of electrical systems in Cameroon. These systems can assist technicians in identifying and rectifying issues more efficiently.

Still, the study recommends that ENEO Cameroon should develop expert systems that provide guidance on energy management and optimization. This can help in optimizing power distribution, reducing wastage, and improving overall efficiency.

2. Fuzzy Systems:

ENEO Cameroon should utilize fuzzy systems for load forecasting and demand-side management. By considering uncertain and imprecise data, fuzzy systems can offer accurate predictions and aid in optimizing power generation and distribution in Cameroon.

Still, they should develop fuzzy control algorithms for voltage control and optimization. This can help maintain voltage stability and minimize fluctuations, especially in grids with intermittent renewable energy sources.

3. Artificial Neural Networks (ANNs):

ENEO Cameroons should deploy ANNs for predictive maintenance of electrical infrastructure. By analyzing historical data, ANNs can identify patterns and predict potential failures, enabling proactive maintenance and reducing downtime.

Still, they should utilize ANNs for optimizing power dispatch and energy scheduling. Neural networks can analyze real-time data, such as weather conditions and demand patterns, to optimize the allocation of power generation resources across the grid.

4. Training and Capacity Building:

ENEO Cameroon should invest in training programs to enhance the skills of engineers and technicians in the field of expert systems, fuzzy systems, and neural networks. This will enable them to effectively utilize these technologies in the management and operation of electrical systems in Cameroon.

Furthermore, they should be collaborate with educational institutions and industry partners to introduce relevant courses and curriculum that incorporate these technologies, ensuring the availability of a skilled workforce for future developments in Cameroon's electrical sector.

By implementing these recommendations, Cameroon can benefit from improved operational efficiency, enhanced power management, and reduced downtime in its electrical systems.

5.4 Limitation of the Study

This researcher examined the impact of AI on electrical systems in Cameroon, and in the process of carrying out the research, some limitations sets in.

1. Access to infrastructure: Availability of necessary infrastructure, such as reliable internet connections or advanced technology, was limited in certain regions of Cameroon. This could affect the implementation and effectiveness of AI systems in the electrical sector, making it difficult to assess their impact.

2. Cultural and social factors: Cultural and social aspects influence the perception and adoption of AI in electrical systems. These factors vary across different regions or communities within Cameroon, and could potentially affect the accuracy and generalizability of research findings.

3. Human factors: The success of AI integration into electrical systems often depends on human factors, such as the adequacy of training, user acceptance, and willingness to adapt to new

technologies. Assessing the impact of AI on electrical systems should consider the human element and any associated challenges.

4. Time constraints: Research projects often have time limitations, which may restrict the scope and depth of the study. Comprehensive evaluation of the long-term impact of AI on electrical systems may require more time and resources than are available for a specific research endeavor.

5.5 Suggestions for Further Research

The researcher therefore suggests that further scholars could research on the following topics:

- Evaluate the impact of AI on electrical systems in Africa.
- Evaluate the impact of AI on electrical systems in Turkey.

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