SVU-International Journal of Engineering Sciences and Applications (2024) 5(2): 7-17
Print ISSN 2785-9967 | Online ISSN 2735-4571
DOI 10.21608/svusrc.2024.258169.1169

A Comprehensive Study of Power Distribution Planning Perspectives: Modelling, Tools, Goals, and Criteria

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Abstract To cope with the recent developments in the energy transition sector, several sustainable and renewable energy resources have been utilized to eradicate the harmful impacts of conventional energy sources. However, their increased integration causes adverse impacts on both the utility grid (UG) infrastructure and performance besides variations in the consumption patterns. So, it is crucial to accomplish accurate power system planning, especially at the distribution level, in order to sustain the acceptable limits of reliability and end-user satisfaction in cost-effective procedures. Several textbooks and articles investigate this important topic. However, the book entitled “Power Distribution Planning Reference Book (H. Lee Willis) 2nd Edition, 2004”, is still an important and comprehensive reference for power distribution planning. Hence, this article proposes a book review and discussion of its most important contributions to power distribution July planning by dividing them into six parts, each part has its subject associated with the planning topic. Which aids the reader in performing an overview conclusion of this book and its contents. Moreover, providing a comprehensive review of this topic in terms of modelling, tools, goals, and criteria.

Keywords:. Power system planning and reliability; sub-transmissions and substations; feeders; consumers; cost.

1 Introduction

To lessen the adverse impacts of conventional energy sources on the environment, various renewable and sustainable energy sources are utilized and integrated into the utility grid (UG) to provide the required energy demands for consumers at low cost [1]. However, these integrated technologies influence the UG performance and reliability besides demanding abundant upgrading of its infrastructure to deal with the new consumption patterns and advanced industrial equipment [2]. So, it is necessary to achieve accurate power system planning in terms of several planning procedures and aspects to sustain the reliable and stable conditions of power system delivery.

The power system delivery is responsible for delivering the electrical energy from the generation stations to the consumers at the distribution level through substations and transmission lines [3]. Thus, several aspects should be considered to measure both the quantity and quality of energy utilization such as power system reliability and flexibility. To ensure acceptable levels of consumers' satisfaction, the power system reliability index measures the power system's ability to provide consumers with a continuous and adequate power supply with a feasible cost to maintain the stability and the security of power exchange [4]. On the other hand, the power system flexibility achieves an effective energy management of all power system components to provide the energy demands with reliable and cost-effective conditions under any generations or consumption uncertainties [5]. Hence, power system planning is important to deal with the previous aspects as it is responsible for scheduling various aspects of power system components' overall energy exchange levels from generation level to consumption level at a given planning horizon, such as implemented time, capacity, location, and cost. It also includes the current and future strategies of energy utilization expansions and how the UG infrastructure will satisfy them. Moreover, it helps to reduce the adverse impacts as a result of integrating new industrial technologies [6].

Several articles and textbooks have been investigated the power system planning in terms of different aspects

Received: 25 December 2023/ Accepted: 3 January 2024
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such as components, requirements, tools, guidelines, and others [7]–[10]. Among them, an important textbook entitled “Power Distribution Planning Reference Book (H. Lee Willis) 2nd Edition, 2004”, presented a comprehensive study of power system planning regarding various directions and topics [10]. Thus, this article proposes an overview discussion about this book’s contributions and contents which are divided into six parts as depicted in Fig.1, to help network planner, students and researchers sustain basic and advanced knowledge about this topic. This book consists of 30 chapters which can be grouped into parts as follows:

- **Part 1:** Principles of power systems.
- **Part 2:** Fundamentals and factors of power system reliability.
- **Part 3:** Power distribution system layout and planning aspects.
- **Part 4:** Planning goals and criteria.
- **Part 5:** Tools and approaches for power distribution planning and load forecasting.
- **Part 6:** Additional planning aspects and guidelines.

Hence, the main contributions of this article can be summarized as follows:

- Investigating the book contents regarding the divided parts separately.
- Highlighting the importance of power system planning.
- Demonstrating benefits to readers & key features.
- Moreover, providing a comprehensive review of this topic in terms of modelling, tools, goals, and criteria.

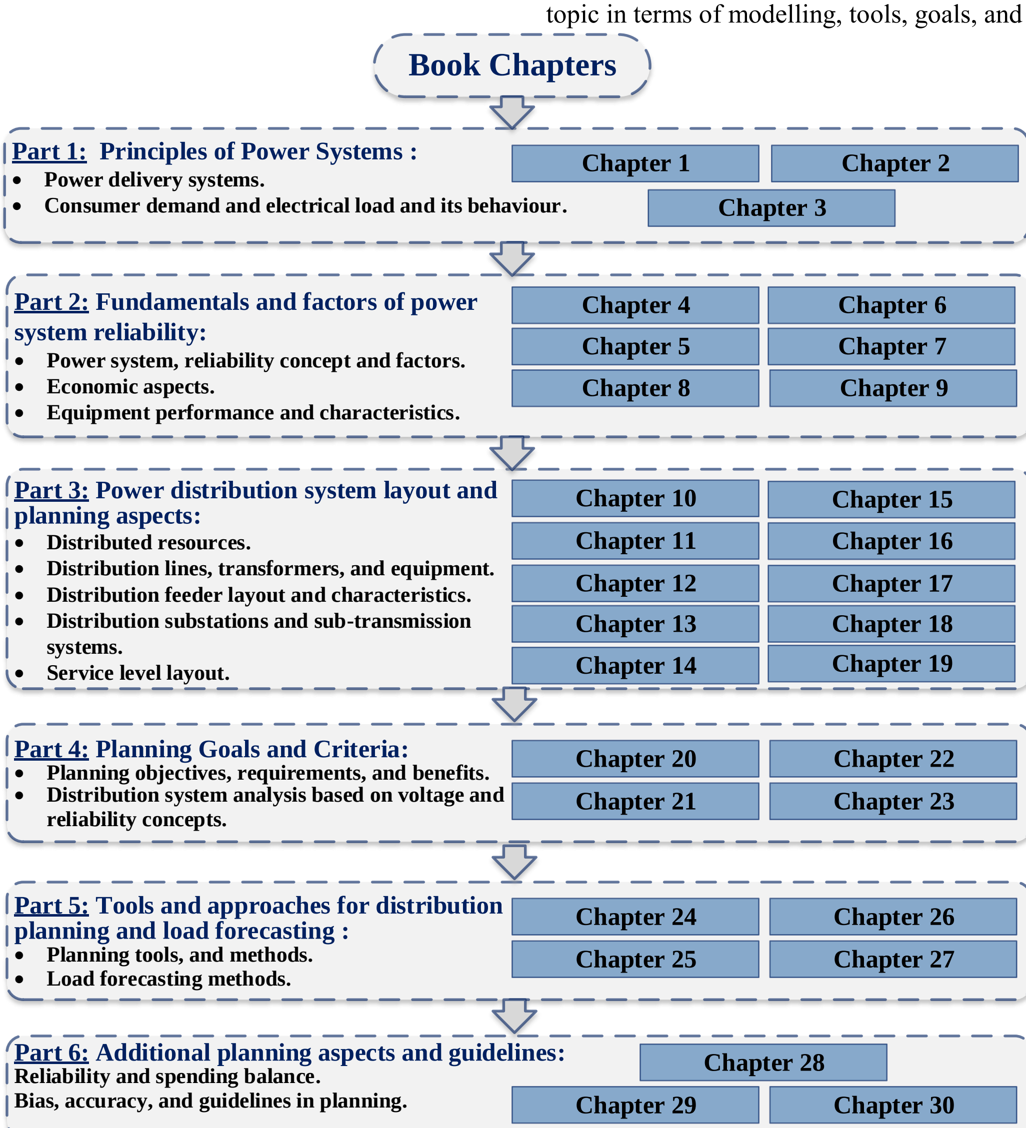

Fig.1 Book Layout.

After the introduction section, the article is organized into sections 2 to 7, discuss the main contributions of the investigated book. Then, following by the discussion and future aspects in section 8. Finally, section 9 gives the work conclusion.

2 Part 1: Principles of power systems

In this section, the power system delivery components and basic construction is discussed beside highlighting the energy demands and consumer behaviors and patterns, which are presented along chapters 1 to 3.

2.1 Power Delivery Systems

In this chapter, the power delivery systems (the transmission and distribution (T&D) system) are responsible for delivering electrical power from production places to consumers with high reliability and low costs. In addition to including the ability to respond to any interruptions in demands within acceptable limits of power quality indices. Power system reliability means that the power system distribution can deal with electrical demands without any power quality issues which can be measured with frequency (number of times happens) and duration. To achieve that, there are three basic requirements of T&D planning which are stated as the T&D system must cover all customers and respond to their capacity with good reliability. In section 1.4, the six natural laws of T&D are mentioned that characterize the main requirements for designing the T&D system such as rules of hierarchal voltage levels.

The T&D system can be classified into generation, transmission, and distribution stages, as depicted in Fig. 2. The distribution stage may be primary or secondary distribution. All of these stages involve substations, feeders, transformers, generation units, cables, etc. All data of transmission, sub-transmission, substation, feeder, lateral, service transformers, secondary and service levels can be changed from one system to another which is dependent on the system configuration and design. In section 1.6, the various utility distribution equipment are discussed such as T&D lines, transformers, switching devices, protection and protective equipment, and voltage regulation elements. Also, the T&D costs can be classified into transmission, substation, feeder system, service level, operation, maintenance, taxes (O&M&T), upgrading, and electrical losses based on both demand and energy aspects, as discussed in section 1.7.

Moreover, section 1.8 discusses types of distribution system design in terms of feeder systems, substation and feeder service areas, and dynamic service area planning. According to the classification of feeder systems, they can be radial systems which are mostly used and have only one electrical path from substation to consumers with low reliability. While the loop (ring, mesh) systems involve two paths between generation sources and each consumer. However, they are complex with compact reliability. Hence, the distribution networks combine the radial and loop systems which can be more complicated and expensive with high reliability. The radial configuration is most used which may be presented in large-trunk or multi-branch feeder layouts. Finally, section 1.9 mentions Two-Q planning methods that mean a distribution system's quantity (demand and capacity) and quality (continuity of sufficient service - reliability). Thus, planners should consider overall costs besides achieving both capacity and reliability, which makes the optimization problem more complicated.

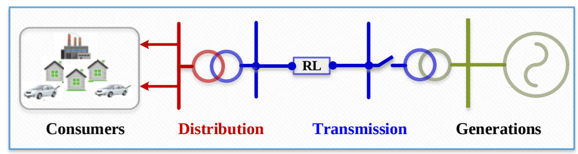

Fig.2 Configuration of utility grid.

2.2 Consumer Demand and Electric Load

In this chapter, consumer demand and electrical load are discussed in terms of two Q planning and cost. Which can be summarized as follows:

- The two Qs planning aspects are quantity (amount of required power), and quality (availability and reliability).
- Besides two Qs aspects, cost is very important for both consumers and utility,
- In section 2.2, the quantity of power demand can be described as Constant Power (power is constant regardless of the voltage), Constant Current (power varies with voltage), and Constant Impedance (power varies with the square of voltage) Loads, as shown in Fig. 3. Moreover, they are specified according to measured data of the country or using the rule of thumb. The power demand can be presented using a load curve or load duration curve with respect to the time period (min., hour, etc.), which are based on consumer classes, and location.
- In section 2.3, the quality of power demand can be assessed using cost. Firstly value-based planning considers the sum of costs (utility and customer value) as a function of reliability, as given in Fig. 4. Also, the cost of interruption is studied in terms of consumer class, location, frequency and duration of them.
- In section 2.4, the consumer values (reliability and cost) based electricity market are depicted as a comb. So, it should be two Q analyses vs. cost in planning, as presented in section 2.5.

2.3 Electric Load, Coincidence, and Behavior

In this chapter, the dynamic and coincidence behaviors of electrical demand are discussed in terms of various definitions. Which can be summarized as follows:

- Peak load is the maximum demand of connected load at a specific time.
- Load demand (appliance duty cycle) is the coincidence of load usage that the load does not work all the time.
- Connected loads are the summation of all load peaks regardless of their run time.
- Coincidence factor: the ratio of observed peak for the group to the sum of individual peaks and it is a reciprocal of the diversity factor).
- The measuring and modelling load curves are based on the accuracy and the resolution (demand sampled) of measurement devices.
- High sampling rates are required only for studying the non-coincident load behavior of small groups of customers.

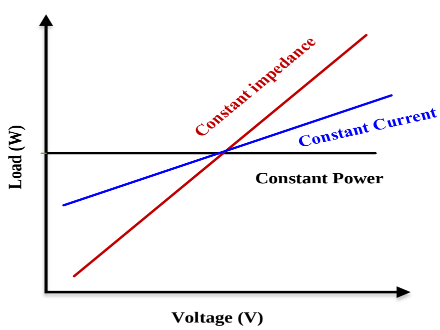

Fig.3 Power demand types.

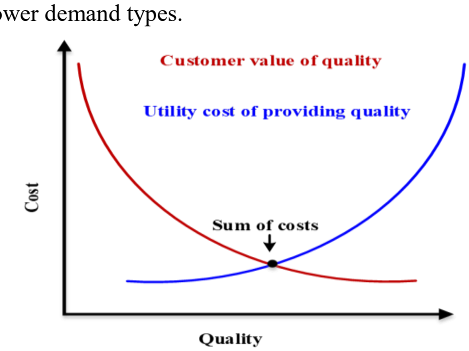

Fig.4 Concept of the cost-based planning as a function of reliability.

3 Part 2: Fundamentals and factors of power system reliability

This part consists of 6 chapters that discuss the concept of power system reliability and its factors. Also, the economic attributes, equipment behavior and characteristics are involved.

3.1 Power System Reliability

In this chapter, the concept of power system reliability is discussed in terms of various definitions, indices, etc. Which can be summarized as follows:

- The textbook stated the definition of power system reliability as is the ability of the power delivery system to make continuously available sufficient voltage, of satisfactory quality, to meet the consumers' needs.
- In section 4.2, the outage and interruption of the utility are investigated. Hence, it can be concluded that outages cause interruptions. The interruptions have several types which are based on the frequency, duration, and extent of them.
- In section 4.3, the most important four reliability indices are discussed. Then followed by an analysis of them and how they can be used to assess and compare various utility performances. The usage of the term benchmarking is established to generalize the comparison.

3.2 Economics and Evaluation of Cost

In this chapter, the economics and evaluation of various types of cost elements are discussed. Firstly, the cost is defined as the total sacrifice that must be multiplied to attain some desired products, which not only is money but also labor, resources, etc. But they are measured on a common basis in money. Then, two types of costs are discussed, which are the initial costs that are required for establishing the project and the continuing costs which are necessary to keep it in operation. Another classification can be categorized in fixed or variable costs. In fixed type, the costs remain constant and don't vary as a function of any business conditions. However, variable one is dependent on other facilities and factors, as depicted in Fig.5. Then, other related concepts are discussed such as revenue requirements, sunk cost, and embedded, marginal, and incremental costs.

In section 5.3, the time value of money is discussed as a decision-making tool which can be "whether a present expense is justified because it cancels the need for a future expense of a different amount". The second cost decision "involves determining if a present expense is justified because it will reduce future operating expenses by some amount". Several factors contribute to making the suitable cost decision for power system planners as concluded in Table 1.

Other factors should be considered in the PW analysis such as interest rate, financial and internal risks, inflation, planning errors, and expected gain or profits. The cost variations can be temporal (peak times), contingency (load levels, losses, economic crises), based on system level (generation, transmission, distribution, LV/ MV), and based on location of power delivery.

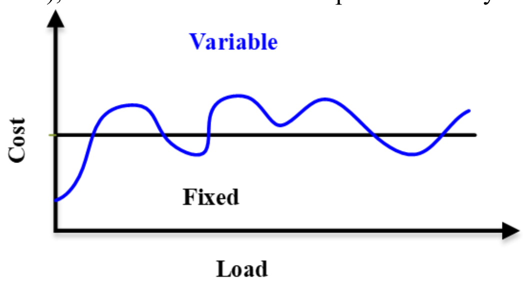

Fig.5 Cost categories.

3.3 Evaluation, Prioritization, and Approval

The planning decision-making process is based on various stages which are evaluation, prioritization, and approval, as discussed in this chapter. The evaluation stage is a process for assessing various items which are involved in a decision such as equipment, projects, alternatives, etc. which should be traceable and fully documented. Then the prioritization stage is responsible for specifying and comparing the priority range of these items and ranking them based on several concerns such as attributes (single or multi.), criteria, and other requirements. After that, the suitable items are authorized in the approval stage which meets certain requirements (completeness, accuracy, valid comparison, and economics) and deals with the attributes restricted by criteria. The rest of the chapter discusses the various decision-making paradigms which are:

- Traditional planning paradigm: it is a standards-driven approach to deal with the obligations and requirements with the least implementation cost. No risk assessment and spending limits are considered.

- The benefit/cost ratio paradigm is used in the evaluation and comparison processes based on the ratio of benefit to cost unless it meets the minimum standards upon optional activities.

- Incremental benefit/cost evaluation: assesses items based on the incremental benefit to incremental cost over certain periods.

- Profit-based planning paradigms: the evaluation focuses on selecting the items that maximize the profits from the investments.

- To sum up, no one paradigm is ideal or better than others and the selection of them is based on the planning projects and situations.

3.4 Equipment Ratings, Loadings, Lifetime, Failure, and System Performance

In these chapters, the various concerns in power system planning are investigated such as equipment rating and capacity, loading, lifetime, and failure. In this regard, the impacts of equipment failures on power system reliability are discussed separately in Chapter 8. The main findings of them can be concluded as follows:

- Knowing the capacity rating for equipment provides a general identification of unique equipment compared to others using the same standards.

- Variations in loading and rating affect the lifetime of equipment (excessive loading means low lifetime).

- There are three factors essential in modelling the lifetime-failure of any equipment (e.g transformer). Firstly, the background failure probability which means that failures can happen at any time without known causes. The second factor is sow and linear deterioration in internal characteristics through putting in service or loading. Finally, an exponential decay in insulation strength.

- Another modelling based on four factors (one is the equipment design and others related to the utilization of equipment) is illustrated.

- The failures can affect not only the lifetime of equipment but also its functions. The failures' consequences are categorized into functional, lifetime, interruption, and catastrophic sorts.

- Other factors influence failures such as ageing and deterioration which can be due to chronological age (natural such as corrosion), cumulative service stress (proportional to service time or loading such as electromagnetic filed or heat stresses, and wear), abnormal event stress (lightning strikes, ice loading), and "technical obsolescence" (equipment not supporting new functions or developments).

- Several steps can be applied to reduce the probability of failures and improve equipment life and reliability such as replacement with new ones, retrofitting or updating functions, refurbishment, overhaul or maintenance, scheduling maintenance based on major services, inspection, and repair regularly, condition,

Table 1 Cost decision factors for planners.

Sr.	Factor	Description	Expression	Notes
1.	Present Worth (PW)	It is a method for comparing and measuring costs and saving at different times.	$G(t) = M * P^t$ Where, $G(t)$ is the equivalent of today's value of money (M) at upcoming years (t), and P is the present worth factor (PWF).	• Low PWF means that the projects and plans should be established today to save additional future costs. • If the PWF is higher than the projects may be delayed until the last moment.
2.	Discount rate (DR)	The discount amount of the future cost value and savings compared to today's costs and savings.	$P(t)\% = \frac{1}{(1+d)^t} * 100\%$ Where d is the discount rate.	-
3.	Levelized Value (LV)	It is used to compare the annual cost of projects to the average annual cost as the cost variations per year.	$LV\ (t) = \frac{Q(d*(1+d)^t)}{((1+d)^t - 1)}$ Q is the sum of total annual costs over t years.	-

evaluation, monitoring, and modelling, and re-rating to save lifetime.

- The rate of equipment failures has increased related to the age in the service.
- The failure time prediction is a challenging task and based on various planners' assumptions.

3.5 Load Reach and Volt-VAR Engineering

In this chapter, the voltage drop is discussed which is influenced by loading, conductor size and distance, frequency variations, space between conductors or phases, and R/X ratio. So, the planners should consider the voltage drop in load research and power transfer through the distribution systems to achieve reliability and cost minimization by implementing voltage regulation techniques, power factor correction elements, feeder configurations, and optimization of various requirements in long-term planning. To manage the voltage drop, volt-var techniques are used such as capacitor banks (shunt, series), power electronic devices (FACTS), etc.

4 Part 3: Power distribution system layout and planning aspects

This part discusses the power distribution system in terms of its layout and planning aspects. Through 10 chapters, various components are involved such as distributed resources, transmission lines, transformers, substations, feeders, and others, besides highlighting their behavior and role in the planning process.

4.1 Distributed Resources

In this chapter, demand-side management (DSM) strategies are discussed in terms of classification, applications, resources, and benefits. The DSM resources involve distributed generators (DGs), RESs, energy storage systems, etc. which can be applied to residential, commercial, and industrial sectors to reduce the cost of energy consumption for consumers and make profits for utility providers. In this regard, the DSM strategies are the most prominent tools in power system planning.

4.2 Basic Line Segment and Transformer Sizing Economics

In this chapter, the components of distribution feeder systems (lines, and transformers) are discussed. Firstly, the line types (overhead or underground, number of phases, etc.) are investigated then the types of transformers are involved in section 11.3. Finally, the economic considerations for selecting suitable lines or transformers are mentioned as important criteria in power system planning.

4.3 Choosing the Right Set of Line and Equipment Sizes

The economic selection concerns of a set of conductors are discussed regarding several factors such as efficiency and voltage drop, operating voltage level, length, and size, loading range, fixed costs, conductor material, and types, and other characteristics, which are essential at the planning stage. Then the selection approach is extended to apply to the transformers' sets.

4.4 Distribution Feeder Layout

In this chapter, the feeder circuit layout is discussed for the planning process from point of view:

- Their types can be radial, loop (mesh or ring), and network.
- Their categories can be normal, urban, and rural geography which are based on capacity, voltage drop, and cost constraints.

- The different voltage levels (dual voltage degrees) and their economic usage in the feeder layout design.

4.5 Feeder Layout, Switching, and Reliability

In this chapter, several important topics for power system planning are discussed which can be summarized as follows,

- Feeder layout and design are discussed by highlighting the interaction with reliability in terms of configuration, capacity, selection, and switch time.
- Responsibilities of engineering standards, operations, and distribution engineering or planning departments.
- Two important concepts; sectionalization and switching design.
- The contingency strength of the feeder system that measures the average ability to transfer load from one substation to another.
- Contingency support and switching design with their associations to reliability.
- The protection systems of feeder layout in terms of configuration or equipment such as over voltage /current protection systems, and sensors or relays, respectively.

4.6 Multi-Feeder Layout

In this chapter, the various planning process aspects of multi-feeder layout are considered. Firstly, the number of feeders should be specified and their components' characteristics such as conductor size, length, and material, line capacities and constraints, and load reach. Then, the most important planning concerns, goals, and steps of the multi-feeder system are discussed associated with forecasting the load growth and overall cost estimation.

4.7 Distribution Substations

This chapter examines the most important components, configurations, and requirements for substations. Both high-side and low-side levels are discussed in terms of equipment and configuration which are based on the number of incoming transmission lines (high-side) or output feeders in the low-side, reliability, cost, switching and contingency backup, and protection systems. Other aspects such as substation site, capacity, costs, reliability, and requirements, are considered in the planning process.

4.8 Distribution System Layout

The distribution system layout considering capacity, voltage level, losses, and cost aspects is discussed. Then, the design requirements are given in terms of cost, electrical performance, and reliability by highlighting the main relationships and interactions among them and calculation methods, which are based on load density and conductor size variations and their influence on substation and feeder costs.

4.9 Substation Siting and System Expansion Planning

The planning decisions of substations and sub-transmissions are involved to highlight the relationship of selecting their location, service area, start-up time, capacity, and other aspects, with the overall cost. Followed by highlighting the strategies and guidelines of the planning process to achieve the optimal design of distribution systems and low cost while sitting and sizing the substations and sub-transmissions.

4.10 Service Level Layout and Planning

This chapter discusses the planning process and layout approaches of power distribution systems at the service level in terms of their configurations, voltage level types (American or European), and load dynamics. Also, some layout methods (table-based or computerized-based) and required arrangements to sustain the service level with high reliability.

5 Part 4: Planning goals and criteria

This part presents the planning goals, benefits, and criteria regarding voltage or reliability analysis.

5.1 Planning Goals and Criteria

The planning goals, guidelines, and criteria are highlighted starting from section 20.2 which discusses the voltage and customer service criteria and requirements, especially for the primary distribution level such as voltage rating, voltage violations, and voltage imbalance. In section 20.3, other criteria are discussed such as fault current limits and the guidelines of protection systems followed by the guidelines and criteria for load rating, equipment, and design.

5.2 Reliability-Related Criteria and Their Use

Other criteria are outlined based on reliability and how to achieve it in power delivery planning. Firstly, the reliability indices, objectives, and criteria are given in section 21.2. Then, the practical issues and the applied approaches related to reliability planning are depicted.

5.3 Distribution Circuit Electrical Analysis

This chapter discusses the load flow analysis of the given circuit based on voltage guidelines and criteria by examining the application of analytical tools for distribution planning. Moreover, it gives a brief description of circuit models and their configuration which involve utility (AC, DC), model representation (balanced/unbalanced three-phase system, single phase, DC system), equipment (transformer, motors), load (constant power, constant current, constant impedance), power factor correction elements, lines and feeders, and other elements.

5.4 Distribution System Reliability Analysis Methods

This chapter discusses the load flow analysis of the given circuit based on reliability guidelines and criteria by highlighting several points, as follows,

- Some concepts related to reliability and distribution planning are given.
- Section 23.2 investigates the contingency-based planning approaches such as N -1 Criterion, to ensure system operation within constraints and high-reliability levels.
- Section 23.3 discusses the capability of managing the power system reliability similar to other performance aspects such as voltage or power factor.
- Sections 23.4 and 23.5 focus on the analytical methods (Monte Carlo simulation) for reliability and provide an example for applying them in medium-sized power systems, respectively.
- In section 23.6, the required approaches for evaluating and optimizing the financial risk are supported by the analyzed example.

6 Part 5: Tools and approaches for power distribution planning and load forecasting

To ensure accurate power system planning, this part illustrates the important planning tools and strategies, and the role of load forecasting in the planning process.

6.1 Automated Planning Tools and Methods

This chapter discusses the optimization methods (such as Genetic algorithms (GA, Linear programming (LP)) as a planning tool which is based on identifying the available variables initially, then evaluating them regarding the required criteria and attributes, and selecting the best case in the final. Moreover, it discusses the application of optimization algorithms for determining optimally the feeder system layout, substations, and distribution system design.

6.2 T&D Load Forecasting Methods

For the planning process, it is essential to use load forecasting methods to expect the amount, time, and location of energy demands that should be delivered to the consumers. This chapter highlights the significant importance of load forecasting methods in the planning process by discussing several points, as follows:

- The hosting capacity enhancements for the utility are essential to deal with the rapid energy demand growth because of new customers' incremental, and deployment of new electrical applications.
- Important variables should be considered in spatial load forecasting such as forecast accuracy, customer classifications, peak demands, etc.
- The trending methods are used for spatial load forecasting such as polynomial, and geometric and cluster-based curve fitting.
- Simulation methods are used to analyze and forecast the load growth.

6.3 Planning and the T&D Planning Process

To deal with the planning objectives, this chapter discusses the T&D planning process to maintain the power delivery to consumers with low cost and acceptable levels of reliability. Section 26.2 gives the most important planning objectives, priorities, and policy-making process. Section 26.3 highlights the five-step process for choosing the best case of planning. In section 26.4, the differences between short-term and long-term planning are highlighted. Then, the uncertainties and muti-scenarios of variables are considered in the power delivery planning process for all system levels such as transformers, feeders, substations, etc.

6.4 Practical Aspects of T&D Load Forecasting

This chapter examines the practical applications of load forecasting which is mandatory to the T&D planning process. Also, several factors that influenced the planning process are mentioned such as weather, cost, data requirements, period, required criteria, and guidelines. Then, the steps of selecting the best load forecasting methods are discussed based on the required accuracy, variables' uncertainties, and other recommendations.

7 Part 6: Additional planning aspects and guidelines

This part involves the moral aspects and guidelines of power system planning while highlighting the interaction between reliability and expenses.

7.1 Balancing Reliability and Spending

This chapter discusses the methods for achieving the balance between the reliability implementation and the applicable cost while highlighting the various planning and optimization concepts and procedures. The cost analysis indices are presented as reliability-based planning tools in various practical applications. Then, the remaining sections summarize the requirements for reliability improvements with low-cost system designs while evaluating the results obtained from several approaches based on both reliability and financial performance management.

7.2 Objectivity, Bias, and Accuracy in Planning

In this chapter, the formal documentation of the planning report and its contents is demonstrated according to various planning studies which are classified based on purposes and objectives. Moreover, the reasons for bias toward one planning result than others, are discussed and the exhausted efforts to get rid of them. In section 29.4, the three rules for cheating that are used by planners are illustrated and how reviewers evaluate the results and clues to discover the cheating. Followed by section 29.5 that discusses the popular areas that may include bias in planning results supported with several examples in section 29.6. Finally, the guidelines are given for reviewing planning reports which include bias, cheating, or mistakes.

7.3 Key Points, Guidelines, Recommendations

The chapter gives an overview of the most important elements of the power distribution planning process in terms of key points, priorities and goals, guidelines, challenges, and recommendations. Moreover, it summarizes the main points that were discussed along with the book chapters.

8 Discussion and future outlooks

This book covers an important topic in electrical power engineering and made it suitable for academic researchers, post-graduate students, UG operators and investors, and network planners. This book presented a comprehensive discussion about power distribution planning from basic to advanced topics. However, it involves several limitations which can be summarized as follows:

- It doesn't cope with the recent developments in the planning field and other integrated technologies in the UG, as this book edition was published in 2004.
- According to the author's opinion, this book is nearest to being a philosophical book than a scientific one with extensive explanations.
- It is more convenient for researchers and planners who have experts in this field.

Generally, it is considered a vital comprehensive book for this research topic. Moreover, the future perspective of the power distribution planning can be summarized as follows,

- Involving the deployment of smart grid technologies, and the integration of renewable energy sources.
- Application of advanced analytics and artificial intelligence (AI) techniques for planning and optimizing the energy demand regrading to the availability and uncertainties of generation sources using advanced control and communication systems in convenient UG infrastructure.
- Dealing with challenges in efficient power distribution include aging infrastructure, outdated equipment, and aging cables, leading to higher transmission losses and power outages.

For more specifications of these previous points, the future aspects can be given in terms of several planning considerations as follows,

a. Smart Grid Integration:

- Implementation of advanced technologies to enhance grid intelligence.
- Integration of smart sensors and communication

systems for real-time monitoring and control.

b. Renewable Energy Integration:

- Increasing focus on incorporating renewable energy sources into the power distribution system.
- Advanced planning for the integration of solar, wind, and other clean energy sources.

c. Distributed Energy Resources (DERs):

- Planning for the integration of decentralized power sources such as rooftop solar, energy storage systems, and microgrids.
- Strategies for managing bidirectional power flows and ensuring grid stability.

d. Energy Storage Solutions:

- Incorporation of energy storage technologies to address intermittency issues of renewable sources.
- Optimization of storage systems for peak demand management and grid resilience.

e. Demand Response Programs:

- Implementation of demand response initiatives for efficient load management.
- Integration of smart meters and communication networks to enable real-time demand-side adjustments.

f. Data Analytics and AI:

- Increased use of data analytics and artificial intelligence for predictive maintenance and fault detection.
- Optimization of power distribution through predictive modeling and machine learning algorithms.

g. Cybersecurity Measures:

- Enhanced focus on cybersecurity to protect the power distribution infrastructure from cyber threats.
- Implementation of robust protocols and technologies to secure data and control systems.

h. Grid Flexibility and Adaptability:

- Planning for a more flexible and adaptive grid infrastructure to accommodate changes in energy consumption patterns.
- Strategies for rapid response to unforeseen events or emergencies.

i. Electrification of Transportation:

- Planning for the increased demand on power distribution systems due to the electrification of transportation.
- Infrastructure development for electric vehicle charging stations.

j. Regulatory Frameworks:

- Adaptation of regulatory frameworks to encourage innovation and investment in modernizing power distribution.
- Development of policies that support the transition to a more sustainable and resilient grid.

k. Community Engagement:

- Involvement of communities in the planning process to address local needs and concerns.
- Development of collaborative approaches for sustainable and inclusive power distribution.

l. Resilience Planning:

- Planning for resilience against extreme weather events, natural disasters, and other potential disruptions.
- Implementation of grid designs and technologies to minimize downtime and improve recovery times.

9 Conclusion

To sum up, this article proposes a book review about an important textbook in the field of power distribution planning. The book is classified into 6 parts, each part has its own contribution and chapters. The book succeeds in covering this topic with comprehensive discussion; however, it is considered a philosophical book with extensive explanations. Moreover, the recent developments in this field are not included as the edition version hasn't been updated yet since 2004.

Moreover, the main book contributions can be summarized as follows:

- Power system planning involves carefully considering various factors to ensure the efficient and reliable generation, transmission, and distribution of electricity.
- Two Q planning aspects with cost reduction are crucial for power delivery systems to perform their role.

- Two Q planning aspects with cost reduction are associated with load consumption and consumer class/consumption pattern.

- Reliability measure is based mainly on the analysis of frequency and duration of interruptions.

- Specification cost aspects and evaluation are important factors in the planning process based on required reliability, and planning time and location.

- In planning process, both decision-making stages and paradigms are essential each has its advantages or disadvantages.

- Variation in loading and rating, and failures occurrences effect on equipment lifetime as important planning aspect.

- Analysis of the voltage drop over the power system and implementing industrial technologies to reduce it, is considered the most important goal of the planning process in long-term.

- Demand-side management is an important planning aspect towards reliable and cost-effective power supply.

- Analyzing the power system components (lines, transformers, substations, feeders) in terms of characteristics and economic benefits, and studying their influences on the power system operation, are required for the planning process.

- Planning requirements and guidelines are based on voltage analysis or reliability study.

- Planning and load forecasting methods and tools have an important role in selecting the suitable planning process.

- Additional planning aspects should be considered such as relations between reliability and spending, and factors in planning reports.

CRediT authorship contribution statement

Hossam H. H. Mousa: Conceptualization, Writing - Original Draft. **Karar Mahmoud:** Writing - Review & Editing, Supervision. **Matti Lehtonen:** Writing - Review & Editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

- The researcher (Hossam H. H. Mousa) is funded by a full scholarship (Long-term Mission System) from the Ministry of Higher Education of the Arab Republic of Egypt.

- This research was supported by the grant of the Ministry of Research, Innovation and Digitalization, project number PNRR-C9-I8-760111/23.05.2023, code CF 48/14.11.2022.

Data availability

No data was used for the research described in the article.

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