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Importance of Power System Planning in Developing Countries and its Emerging Issues

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Abstract*— The power system planning in each developing country has to face enormous hurdles of varied nature. To give an example, the electric power load demands are always uncertain. Hence, their future growth entirely depends on how the load forecasting methods are applied, and they produce the major constraints, basically because of problematic and unplanned procedures of investment, the type, and availability of fuel required developing electric power. This poses further consolidated problems in the remote country regions, where the immediate raw material availability poses problems. They also need to generate the major prerequisites for future power developments in almost all the remote regions, which are normally met by means of state and privately managed electric grids, or else, the power is accessed from the adjoining country or regions. Furthermore, the electric power managing authorities must provide specific assurance to guarantee the power supply to every household and industry instantly and frequently on a uniform methodical basis, at the required time, to gain the level of reliability and assurance for the consistent power supply at the acceptable and realistic cost. The power system planners should curtail these obstacles by encountering whatever difficulties come on the way by proper planning, and by sound management, taking appropriate decisions to construct the requisite capacity power plant, and also by streamlining the transmission and power distribution network. This review paper explores the very vital issues and problems concerning electric power generation and supply by exploring all the challenges to meet the electric power demand in the developing countries.

***Keywords*— Developing countries, distribution network, electric power facility, electricity demand, future load forecasting, power system planning**

I. INTRODUCTION OF POWER SYSTEM PLANNING

Electricity supply procedures on a global basis are trying to balance multiple challenges, starting from the security of energy, environmental access and public health matters. Simultaneously, the landscape of energy is getting a constant transformation due to three disrupting trends creating a status quo. They are fresh and additional cost-effective techniques applied, inclusive of variations in energy efficiency, renewable energy, storage facilities on a larger scale and generation of small and instant load distributed deployment wherever needed. There is a complexity of the dynamic interface between their controls and components [1]. The main division is between the electrical and mechanical subsystems as indicated in the below figure. The electrical section contains mechanical dynamic components like TCUL-Tap-changing-under-load, Motor loads, Transformers and so on. The mechanical section contains electrical dynamic components like process control, auxiliary motor sectional drives, and so on. Moreover, the sides are attached by control and monitoring energy control functional centre [2].

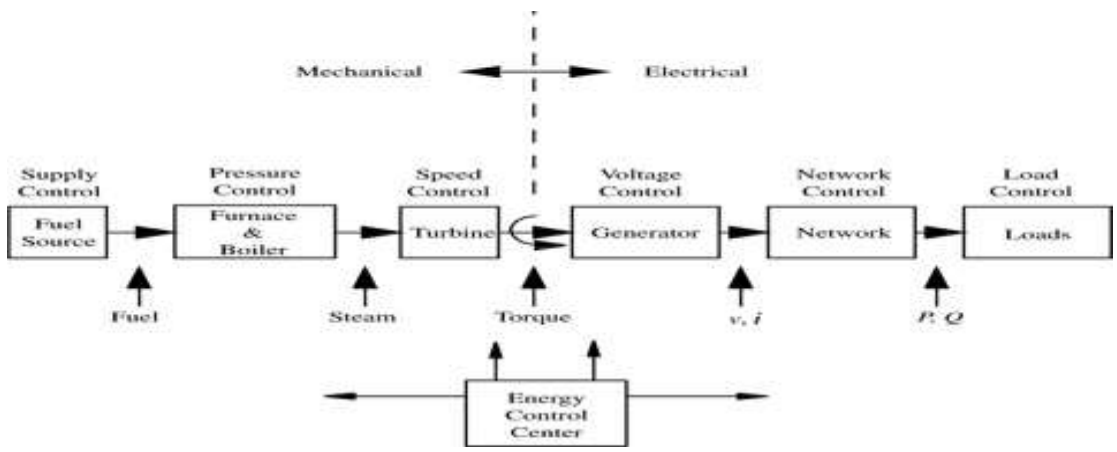

Fig.1. Structure of System Dynamics [3]

The developing countries have good news concerning the power system planning in and its emerging issues. The proper power supply system planning, operation and control in developing countries can meet the expected load demand and provides an indication of the quantity of electric power and capacity needed [4]. The use of dynamic investment plan assessment has been originated in the USA where regulated utility applies this approach to justify investments in the new power plant of the requisite capacity. The dynamic plan of investment, the utility analysis and the economic viability of a new system-level power plant can measure the precise operating profile of the plant with an appropriate investment can result in the lowest electricity cost to the consumer. The major concerns are Generation, Transmission, and Distribution [5].

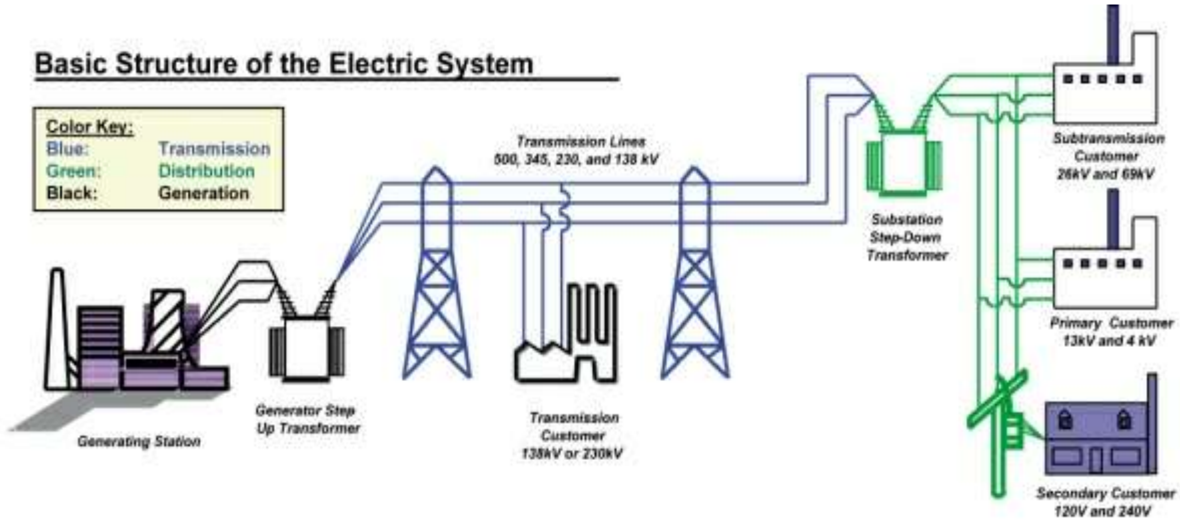

Fig. 2. Basic Structure of electricity planning needs [6]

Therefore, in the USA, the correct assessment has suddenly become the major recognized industry practice, while the precise utility and requisite regulators have acknowledged that dynamic model can provide highly accurate information for the investment planning procedures to take proper investment decisions. This plan and approach must be extensively discussed and implemented for the benefits of developing countries [7].

The careful planning of electric sector is very vital and of high value because it involves several commitments of many resources, containing potentially vast economic measures and risks for the entire utility of electricity and the entire economy of the whole and basic Electricity needs. Several electricity indices are applied to measure and evaluate the economy of the country, their consumption pattern, electricity production per capita and the living standard enjoyed by the people that include the consumption of electricity per capita in the domestic sectors. Furthermore, the supply of electricity holds a unique feature which makes their service exclusive when compared with any other products produced by the industry. The final electricity product must be delivered automatically and instantly based on the demand of the consumer; besides electric batteries, pumping plants for storage, while the technologies are not available to produce electricity at the most economical and uniform level and rates everywhere. Also, it cannot be held in storage on a large scale to deliver under opportune schedule. The shortage and insufficient capacity, at times, excessive or idle capacity generates negative results on the entire economy of the situation. There is a close interconnection with social factors and economic conditions that imposes financial aspects, environmental conditions, labour force, and several other constraints generating more problems [8].

II. METHOD OF POWER SYSTEM PLANNING

The electric power system and planning study are to evaluate and determine the best available system pattern for the electric energy expansion system to meet the needed electric power of the developing countries over a specific given time period. The planning of nuclear power studies performed by the IAEA as requested by the Member States [9] performed with the identical aim, but particularly emphasizing the estimated and possibly nuclear power participation in the best possible expansion pattern. In fact, the task performance must estimate and compare cost benefits, analysing direct as well as indirect effects of alternative ways of pattern development, so as to determine the plan of power expansion to yield optimum net benefits. Due to extreme time limitations, a number of simplifying assumptions can be obtained and they are unavoidable.

The WASP- Wien Automatic System Planning Package methodology applied is an attempt to achieve an understanding of practical and theoretical constraints with consistency. The additional courses and training on the planning of electric system expansion applying the WASP operated methodology are expected to improve in the future years [10]. The major methodology components involve:

● A cost definition benefits for the development of methods must be considered to estimate the quantitative measures and values.

- Criteria of selection for comparing cost stream and benefits extended over time, containing foreign and domestic currency components in inconsistent proportion.

It was predicted that the entire costs instead of net benefits become the correct yardstick measure, and this was vital to assume many expansion programs of electric power to meet the expected demand imposing constraints on consistency in overall benefits and the minimum cost programs eventually provide advantages to the final consumers [11].

The direct costs resulting directly to the production of electricity by using a specific type of plant were considered and taken for considerations. In specific, these external costs arose out of escalating environmental pollution due to fossil-fuelled locations or due to comparatively higher thermal pollution, due to the nuclear locations, which were not considered in the initial analysis. The strict environmental imposition and control by industrial countries can lead to more fuel and capital costs of the thermal power station indicate that the external costs can easily turn out to be the internal costs over time. These types of cost involved in the formation of electricity production and generation grid define the total cost to the economy instead of costs to the producers of electricity [12]. The main consequence of such criteria is to abolish taxes on every fuel and input costs of all types of equipment. This develops a critical assumption in certain countries, which impose a large fiscal burden on certain kinds of fuel, specifically on fuel oil. These concerned countries must take the appropriate and the best judgment regarding their tax policies, which can include the elements of social benefits, not concerned with this study. The utility aspects of the electricity, certainly consider a tax on equipment and fuel as cost elements, while the alternative calculations treating element of taxes as the cost, and that can be agreed for such cases, which normally emphasize critical differences and measures in the final result of electricity costs [13].

III. TYPES OF FORECAST IN ELECTRICAL LOAD POWER SYSTEM PLANNING

The electrical load power system planning is the most essential part of the entire process for a sustainable and reliable electricity future. It is called the LTEP- Long-Term Energy Plan. The LDC- Local electricity utility and distribution companies are liable for the power distribution of electric transmission power lines to every home of the people. The local utility companies, the IESO- Independent Electricity System Operators are answerable to supply electricity, questions regarding billing, interruption of power and use of energy. The local electricity companies must plan properly to prepare the electricity needs of all the homes, hospitals, industries, shops, institutions in their region by assessing the overall electricity needs for the consistent and regular power supply system of today, tomorrow and several months ahead, and also perform proper planning to make certain that the electricity will be made available whenever and wherever needed in their jurisdiction. Their responsibility involves broad commitment with organizations, individuals, and institutions, which can be highly impacted by their decisions. It becomes an iterative procedure to measure short, medium, as well as a long-term supply of electricity requisites as they impact on the environment, reliability, cost and many other factors [14].

The planning process dedicated to particular regional, local, or provincial geographical areas, with specific timelines are:

- The short and virtual time forecast;
- To 18 months planning;
- A Long duration outlook and planning.

A. Local System of Distribution and Planning

The many LDC across the regions can effectively plan by forecasting the electricity needs; properly control the management and operations as the part of their distribution system, so as to supply electricity to all business houses and residential facilities in their region. There are many departments and facilities in LDC to plan and forecast the needs. The regional planning division should consider the reliability requirements at the local level as the measure of their regional planning procedure. The IESO should coordinate and communicate effectively with LDC in the process of regional planning to make sure that the infrastructure of the regional level is capable of meeting both local and regional requirements for the effective and consistent power delivery to businesses and homes. The REPI - Regional Electricity Planning Info graphics should be educated to perform proper regional electricity need planning to identify the electricity needed for every hour, day and month to link the regional needs, by performing the connection between local and provincial planning [15].

IV. TYPES OF ELECTRICAL LOAD FORECASTING METHODS

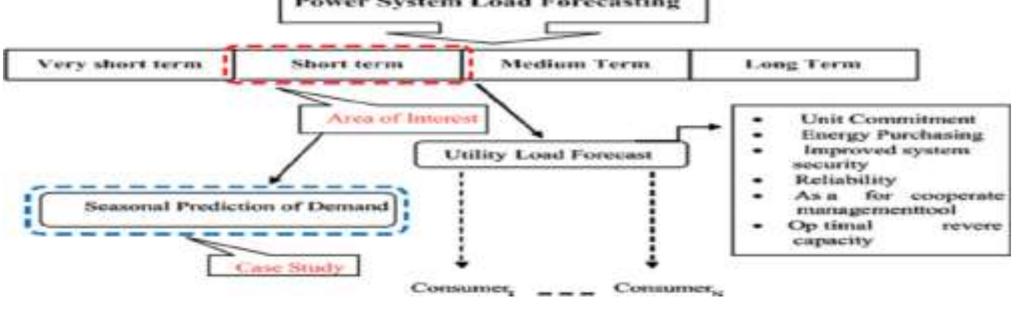

Fig.3. The main methods are very short term, short term, medium term & long term [16].

Apart from the above main methods, there are further methods to substantiate the facts.

A. *Naive Forecasting Method*

It is based on the future projection for a certain period on the basis of the past data evidence and documented for a past duration. For instance, a naïve forecast can be identical and equals the prior period of time, or otherwise, the actual average for the specific prior periods. Such naïve forecasting does not permit to make adjustments to the past period records for any seasonal variations or any changes in the cyclical trends to properly estimate and forecast the future needs. The naïve forecasting user by understanding this method is not alarmed by the causal factors, which result in actual changes at any certain occasion. Because of this reason, the method of naive forecasting is specifically applied to forecast and check the ultimate results of highly sophisticated methods of forecasting [17].

B. *Quantitative & Qualitative Forecasting Methods*

The opinions and views of people construct the baseline of the method with qualitative forecasting. Whereas, the quantitative method mainly relies on previously available numerical data for the prediction of the future needs. The informed opinions by the Delphi method and the life-cycle historical analogy derive the qualitative method of forecasting. Otherwise, the multiplication seasonal index, exponential simple smoothing, weighted and simple moving average measures and methods provide the quantitative values of forecasting.

C. *Casual Forecasting Method*

Are autoregressive and regression analysis moving an average of exogenous inputs is a causal forecasting method to predict certain variable applying fundamental factors. The methods predict that the function of mathematics using known existing variables is utilized to forecast future variable values [18].

D. *Judgmental Forecasting Method*

The scenario of the building using the Delphi method, with a statistical survey and the composite forecast is a judgmental method of forecasting, derived from the estimated value of subjectivity and intuition. They produce predictions depending on opinions collected made by related people and the expert panel of representatives in the survey.

E. *Method of Time Serial Forecasting*

It is like trend analysis, moving average, and exponential smoothing, employing the historical data to evaluate the future outcome. It is a set of data recorded over a certain period, like a quarter of the year 2010 or the annual electricity production since 2000. The previous data pattern normally repeats in the future, and hence, uses a time series to forecast a long-term prediction, for a number of years [19].

V. GENERATION OF ELECTRICAL LOAD PLANNING

The electric power function and system function is to supply a consistent, reliable and constant electricity whenever needed. To provide such instant services, the three prime main electric power component system, like

- Generation of electricity;
- Its transmission; and
- Effective distribution.

To supply electrical needs should be performed as and when required. This generation system is the physical capability to transform energy resources like oil, coal, uranium and so on into electricity. To meet the objective and to assist developing country Members in a peaceful use of the available nuclear energy, an elaborate and comprehensive program must be worked out with proper planning of nuclear power with implementation, and economic evaluations to establish the proper use of nuclear energy in the framework of national energy planning in developing countries. The activities include:

- Developing a proper methodology to be adopted in the developing countries;
- To conduct nuclear power and energy planning, training courses to inform techniques, methodologies to be developed;
- To conduct studies on nuclear and energy power planning in association with all the developing countries.

To improve the future electrical demand, the IAEA has created MAED- Model for Analysis of Energy Demand, a computer model gives a framework of flexible simulation to explore the economic, social, technological influence and policy alterations for the long-term energy demand [20].

VI. TRANSMISSION OF ELECTRICAL LOAD PLANNING

The transmission system does the transportation of the electricity generated to the electricity service providers and communities. The system of distribution in the community impacts the real electricity connections by the transmission process to every customer and helps customers to spend electricity on demand. A dynamic system of electric power balances the supply-demand position.

- The electric supply consists of many designed, physical devices, constructed, maintained, operated, and finally replaced after the device gets worn out.

- The electricity demand changes with time from seconds, minutes, instantaneously to short-term, hours, days, months or years.

Hence, the major aim of electric power is to keep the system continuously balanced for demand-supply effectual. The systematic process includes several advances, like sensor used to measure system condition; equipment to develop electric power line fault detection and current limiters; transformers to regulate the power flow; monitoring with computerized equipments to observe the grid position in real time to perform proper adjustments; and mechanisms to promote reliability, efficiency and control system to safeguard energy infrastructure. The components used should enhance the reliability, safety, and security of the electricity grid [21].

VII. DISTRIBUTION OF ELECTRICAL LOAD PLANNING

The electric power with planned distribution in the infrastructure facilities and buildings is subject to continuous transformation**.** To explore the assigned program with conformity and with assured solution must fulfil the normal needs to optimize efficiency, cost of meeting timely needs [22].

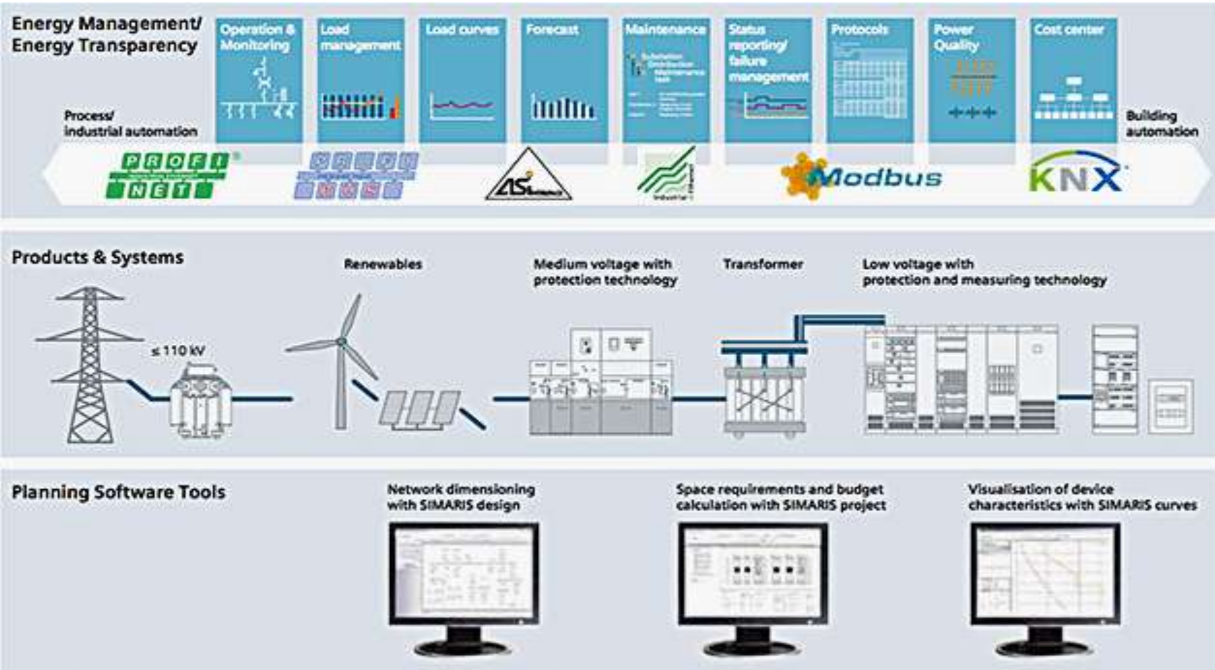

Fig. 4. A complete distribution solution with Integrated Electric Power Distribution [23]

Due to the increasing demand for electricity in modern buildings, at the planning stage, the demand should be met with maximum safety, and flexibility right through the whole Life cycle, with a low environmental pollution level, integrating the renewable energies at low cost to exploit the total potential to meet and fulfil technical demands, with economic efficiency [23].

VIII. RELIABILITY OF ELECTRICAL POWER SYSTEM

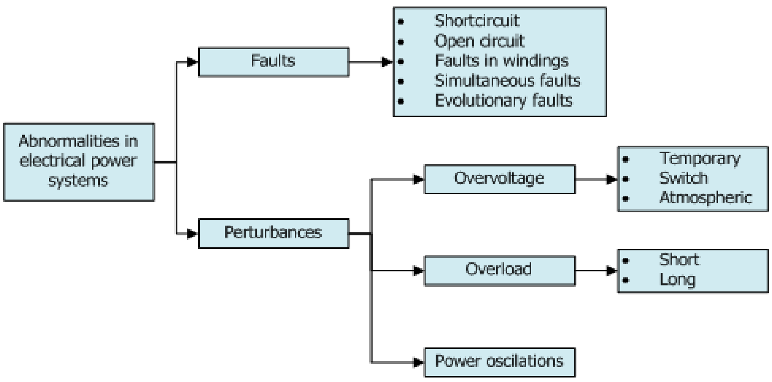

Fig.5. Terminal and operational conditions, with time regime [24]

Reliability against frequent interruption, a number of interruptions hours in one year of operation, is a reliable index to find the device expected to function without failure during the specific time period. The probability is evaluated equipment maintenance needs and total failure rates. This statistical and probability analysis provides the power system reliability in depth with by using the digital computer program. The proper design of the power system, the quality performance factors, reliability and costs are required to select the best design. The constant component failures, system interruptions, and the overall outage rates provide reliability programs to measure the system reliability index at any nodal point of the system, so as to investigate the sensitivity index due to changes in parameters. The reliability and economics of results can provide the ways to select the best design for the power system [24].

IX. METHODS OF MEASURING ELECTRICAL LOAD POWER SYSTEM RELIABILITY

Numerical reliability and its evaluation method define the reliability index for the electric power system, computed from reliability performance knowledge of the constituent components. Various design methods can be considered to assess the service reliability impact on altering the component reliability costs, system protection, configuration, operational mode, system turning policy involving the maintenance practice [25], [30].

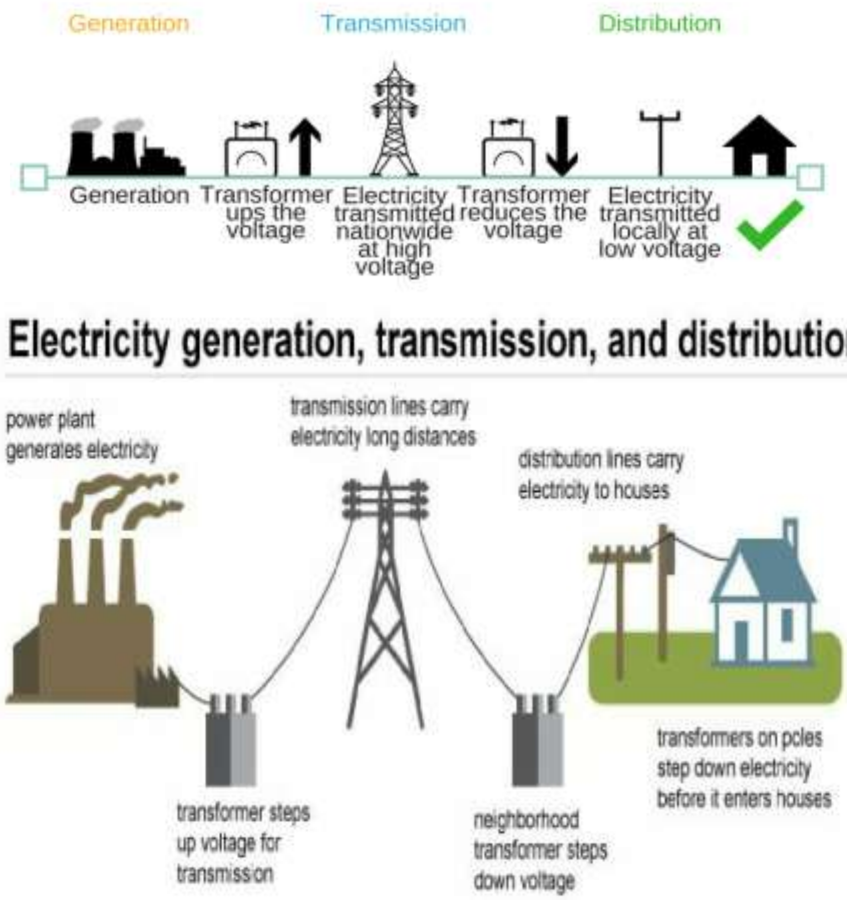

Fig.6. Electricity Generation, Transmission & Distribution [25].

The design of power system includes service reliability consideration needs of load to be delivered and service reliability offered by any electrical system, whose reliability evaluation method is based on the probability theory allowing the reliability aspects of the proposed system to be assessed numerically. Such computing methods allow defensible, consistency and unbiased system reliability evaluation, which are otherwise not defensible, and also otherwise not possible. The indexes of system reliability have proven very helpful in power system design and distribution [26].

X. EMERGING ISSUES IN THE ELECTRICAL POWER SYSTEM PLANNING

Load growth uncertainty of fuel rate and various regulations are the main factors that lead to power-system planning complexity. The constraints and criteria vital to system planning are economic, environmental standards, financial ability, reliability and societal impacts. Certain criteria conflicts with different matters needing certain tradeoffs while making planning decisions. While considering these criteria, an elaborate analytical study is typically needed to simulate the system operation, which projects future conditions to be performed. Various reliability levels attributes and electricity prices estimated from such studies for different structures are evaluated to select a perfect and strong plan. The less the cost along with integrated nonutility, resource planning, generation and purchases as per the capacity is particularly addressed to emphasize the institutional and technical issues implicated in the planning process of electric utility [27].

XI. SOLUTION FOR THE EMERGING ISSUES IN THE ELECTRICAL POWER SYSTEM PLANNING

The numerous activities in the power system planning require certain searching techniques, like Planning and Preparation; Prioritizing distribution network investments; Optimal protection for the placement of switching devices; Generation process of scheduling; Maintenance process scheduling; Operative control and Power mix plans; Restricted load flow; Optimizer of power plant operations; Unit commitment for economic dispatch, these are the solutions for the emerging issues in the electrical power system planning [28].

XII. CONCLUSION

All the electricity sectors are undergoing a significant transformation, of transitions from the static sectors, planned and performed by the central authorities of utilities, planners, regulators, system operators additionally driven by the combination of decentralized operations, technologies and reforms with advanced marketing mechanism. Such changes are generating an environment of basic uncertainty were several challenges arise and they provide new opportunities. For instance, in the power system, there are several complex issues and tasks to be managed by computer control. The energy industry is involved in a large investment for the optimization, apart from the revenue generation and optimization of profits has high value. Therefore, a large segment of technologies has to be described. In such industries, the robust and quick methods are always helpful. Also, in the developing countries, many electric power load optimization techniques and solutions can be applied with constraint programming, linear programming. Performance appraisal is one way to maintain a performance standard in the organization, where the weightage method is applied, along with rule-based systems for progressive improvement of electricity generation, transmission and distribution system [29].

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