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Internal Assesment Test –III

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|---|---|---|---|---|---|---|---|---|---|
| Sub: | Power System Planning | | | | | | | Code: | 18EE824 |
| Date: | 18/06/22 | Duration: | 90 mins | Max Marks: | 50 | Sem: | 8th | Branch: | EEE |

Answer Any FIVE FULL Questions

| | | Marks | OBE | |
|---|---|---|---|---|
| | | | CO | RBT |
| 1 | Explain electricity supply rules, as per electricity act 2003. | [10] | CO4 | L2 |
| 2 | Explain reliability evaluation. | [10] | CO5 | L2 |
| 3 | Explain about trading in electricity market. | [10] | CO6 | L2 |
| 4 | Explain retail market of power market. | [10] | CO6 | L2 |
| 5 | Explain energy efficiency. | [10] | CO6 | L2 |
| 6 | Explain about security requirement and Disaster management. | [10] | CO5 | L2 |

# Answers

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| **1** | **Explain electricity supply rules, as per electricity act 2003.** |

## 6.3 Electricity-Supply Rules

These are the rules of a particular supply authority for electricity distribution system as per Section 50 of the Electricity Act 2003. The rules or distribution code is notified by the State Regulatory Commission. A summary of the points generally covered by this code is given below:

1. Administrative information for grant of connections, billing, connected load, contract demand, disconnection, recovery of dues from defaulting consumers (Section 56) and dealing with theft of energy cases, etc.
2. The system of supply and requirements for balancing single-phase loads on a three-phase system.
3. The limitations placed on water heaters, air conditioners, welders, electric motors, steel rolling mills, arc furnaces, etc.
4. Information regarding service lines, point of attachment of supply and fuses, changeover switches, etc.
5. Provision necessary for all metering including the location, accessibility, and protection.
6. Requirements for consumer installations such as compliance with the wiring rules, inspection, and testing of an installation.
7. System of earthing prescribed and any special earthing requirements.
8. Special requirements, such as limits to low power factor, limits on capacitor installations, harmonics limits for individual consumers at the point of common coupling and rules regarding high-voltage installations. Use of capacitors at the consumer's end should be in such a manner that leading power factor does not occur, particularly at no-load or low-load conditions. The leading power factor causes switching oscillations which are harmful to sensitive electronic equipment.
9. Information of demand, load, and diversity factors of various types of consumers and plants.
10. Tariff application for different categories of consumers.
11. Settlement of consumer disputes, appeals to ombudsman, etc.
12. Guaranteed services standards.
13. Distributed generation rules.
14. Open-access rules.
15. Demand-side management rules.
16. Schedule of general consumer charges.
17. Standard cost data for estimation.

The Regulatory Commission assures consumer protection through continuing enforcement of

1. Service quality, and
2. Guaranteed performance standards.

It can use regulatory tools to get the power utility to achieve the desired results—assist, encourage, reward, punish (fine or penalties, etc.).

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| 2 | **Explain reliability evaluation.** |

## 7.8 Reliability Evaluation

The power system reliability studies are conducted for two purposes.

1. Long-term reliability evaluations may be performed to assist in long-range system planning.
2. Short-term reliability predictions may be undertaken to assist in day-to-day operating decisions including system security. Improvement in system reliability can be effected by using either better components or a system design incorporating more redundancy. The main steps in reliability studies are the following:
   a) *Define the system*: List the components and collect the necessary component failure data from field surveys available.
   b) Define the criteria for system failure.
   c) List the assumptions to be used.
   d) Developing the system model.

e) Perform failure-effects analysis and compute the system reliability indices.
f) Analyse and evaluate the results.

### 7.8.1 Reliability Data

The scope of reliability engineering in power systems depends upon the following:

1. The collection and evaluation of component failure data and load curve model of the system.
2. The definition of reliability measures and the determination of reliability requirements or standards for the various applications.
3. The development of mathematical models for system reliability, and the solution of these models.
4. The verification of the results.
5. The evaluation of results, and the preparation of recommendations.

Data collections and data banks need to be developed to the point where information will be available about all types of equipment, failure modes, and the effects of the various environmental factors and human errors. Methods are to be developed for cost–benefit analysis, and the necessary input information collected. Through such studies, reliability standards can be determined for the system as a whole, for their various parts, and for groups of consumers. Methods of simulation, system partition, and hybrid computation are to be explored for the purpose to evaluate the composite of generation, transmission, and distribution systems. The best allocation of reliability improvement among these parts is to be determined.

The evaluation of uncertainty in load forecasts or load-curve and component data is to be further refined, and these analysis are to be integrated into the overall reliability models.

Short-term reliability methods are to be developed to the point where they can be made parts of online system control programmes.

### 7.8.2 Reliability Programs

A commercial power-system planning computer program (see Chapter 10), i.e., WASP, ISPLAN, EGEAS, which are equipped with several solution techniques, have been used by the Central Electricity Authority for evaluating HLII adequacy. The programs are based on a contingency enumeration algorithm, which includes the systematic selection and evaluation of disturbances, the classification of each disturbance according to failure criteria, and the accumulation of reliability indices. The program provides an appropriate set of adequacy indices at each load bus and the overall HLII indices.

### 7.8.3 Sensitivity Studies

Several sensitivity studies are carried out to examine the effect of the variations in the various power-planning parameters, namely, (i) variations in the electricity demand projection by 10% and 20%; (ii) low level of hydro development; (iii) improvement in performance of thermal power plants; and (iv) improvement in the system-load factor by employing available load-management techniques, etc.

### 7.8.4 System Reliability Analysis

The essence of total system analysis is simulation of system operation with respect to both reliability and economy of electric power supply. The simulation is carried out over a period of time which is estimated to include most of the economic impacts of the alternatives being studied. One way of defining an adequate length of study is that which will produce, among alternatives, differences in present worth of final-year costs which are small compared to differences in present worth of costs for the total study period. The requirement is usually met by study of no more than twenty years' length. The simulation of future system operation is repeated for each alternate case, the present worth of the total system cost of each simulation being the basis of comparison.

It might be argued that a decision, for example, to install this or that piece of equipment today based on study which requires assumptions about conditions twenty years hence is not realistic: no one can predict the future. But it is impossible to escape making assumptions about long-range future when considering equipment of long range life. If one wishes to avoid the uncertainty of future conditions by an economic study based on today's conditions only, he/she is in reality making the assumption that the future will be the same as today, probably the worst assumption that could be made. So assumptions regarding future conditions are necessary; but in total system analysis they are clear, identified, unequivocal assumptions. The 20-year study is not a prediction of the future, but an answer to the question, 'what if these were the future conditions, and I made a certain decision regarding generation?' It should also be noted that a 20-year study is not for the purpose of establishing twenty years' worth of economic decisions: it is to assist in making a current decision using the insight obtained by considering the future.

| 3 | **Explain about trading in electricity market.** |
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## 11.10 Trading

Electricity trading is essential for meeting peak demand and overall resources optimisation. Trading licenses are granted by the CERC. Trading enables better utilisation of existing power resources, affords efficiency benefits for all players in the delivery chain, and ensures better quality of power supply to the end-user. Bidding can be used as a mechanism to decide who should win what, without the determination resting on price competition. Bids are placed for renewable energy certificates (RECs) on power exchanges. Suppliers submit an increasing supply schedule for each hour. The schedule is intended to reflect the marginal cost of operating the unit at various levels. The bidders cannot express directly their true preferences, which are complicated by start-up costs and no-load costs. Consider a bidder with a generating unit that has substantial start-up costs. To express the start-up cost indirectly, the generator must guess how long the unit will be asked to run. For units near the margin, an accurate guess may be impossible. The solution is to allow multi-part bids in which generators bid not only energy but also start-up and no-load costs. The generator can express its true preferences directly.

As per Subsection 26 of Section 2 of the Electricity Act 2003, a licensee participate in trade, the day before, standard hourly contracts and block contracts that commit them to injecting into or drawing from the Inter-State Transmission System (ISTS) a volume of electricity at a given hour at a market price. Transaction can be delivered at any point into ISTS. Hourly contracts provide considerable flexibility by allowing operators to fine-tune over the delivery day (purchase additional electricity or sell excess). Block contracts correspond to the needs of participants who want to buy or sell set volumes of electricity over several consecutive hours, corresponding to identified periods in the day (peak or base), or separate hour periods through the following delivery day. Matches bid and offer for each time block for the next day. On the day-ahead market exchange platform, market participants can place their buy or sell bids for the next day of 24 hours. The delivery of power starts from 00:00 hours of the next day and continues till 24:00 hours. It is important to mention that the exchange platform in India allows double-sided bidding. Orders are placed between 10 a.m. to 12 p.m. of the previous day with a minimum volume of 10 MWh. The delivery point is the interconnection point of the state grid with ISTS, the regional grid managed by POSOCO. The system price in the day-ahead market is, in principle, determined by matching offers from generators to bids from consumers at each node to develop a classic supply-and-demand equilibrium price (which determines the spot price at each trading interval for each bid area/region), usually on a 15-minute, or 30-minute, or hourly interval, and is calculated separately for subregions in which the system operator's load-flow model indicates that constraints will bind transmission.

After getting confirmation for transmission capacity for trades, transmission congestion is managed by *market splitting*. The system then will calculate Market Clearing Price (MCP) and Market Clearing Volume (MCV) as shown in Fig. 11.6. MCP (average, peak, non-peak, maximum, minimum) will be determined for each bid area as shown typically in Table 11.1:

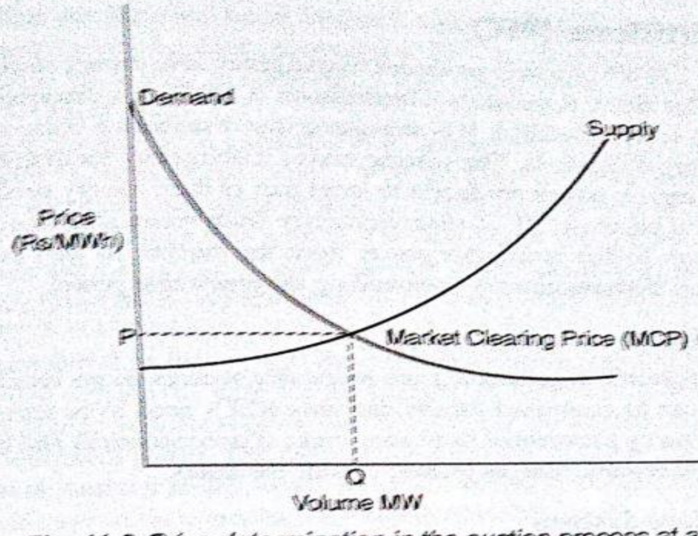

Fig. 11.6 Price determination in the auction process at a node

Table 11.1 Bid areas

| Serial No. | Bid area | Region | States |
|---|---|---|---|
| 1 | N1 | North | Jammu and Kashmir, Himachal Pradesh, Chandigarh, Haryana |
| 2 | N2 | North | Uttar Pradesh, Uttaranchal, Rajasthan, Delhi |
| 3 | N3 | North | Punjab |
| 4 | E1 | East | West Bengal, Sikkim, Bihar, Jharkhand |
| 5 | E2 | East | Odisha |
| 6 | W1 | West | Madhya Pradesh |
| 7 | W2 | West | Maharashtra, Gujarat, Daman and Diu, Dadar and Nagar Haveli, North Goa |
| 8 | W3 | West | Chhattisgarh |
| 9 | S1 | South | Andhra Pradesh, Telangana, Karnataka, Pondicherry (Yanam), South Goa |
| 10 | S2 | South | Tamil Nadu, Kerala, Pondicherry (Puducherry), Pondicherry (Karaikal), Pondicherry (Mahe) |
| 11 | A1 | North East | Tripura, Meghalaya, Manipur, Mizoram, Nagaland |
| 12 | A2 | North East | Assam, Arunachal Pradesh |

## Renewable Energy Certificate (REC)

An REC, which represents 1 MWh of power produced from a renewable energy resource, is tradable at power exchanges. The Central Electricity Regulatory Commission (CERC) has launched the renewable energy purchase obligation (RPO) scheme in 2010. It is stipulated that distribution companies will be penalised if they do not meet green energy obligations. The scheme makes it obligatory for distribution companies, open-access consumers [7], and captive power producers to meet part of their energy needs through green energy. State utilities are required to purchase 5% of their electricity from renewable sources. Users prefer RECs, which are valid for 365 days, to buy renewable power from the market, as they do not involve inter-state scheduling and shield traders from uncertainty surrounding the renewable power.

### *1. Interstate Transmission*

RECs issued for quantum of electricity generated from renewable sources do not require scheduling over long distances. Such electricity can be consumed locally and only RECs need to be transferred to the obligated entities. Renewable obligation by preferential tariff may make it uneconomical and technologically difficult to transmit electricity from renewable sources located outside the states.

### *2. Promotion of Standalone Systems*

Since trade in RECs does not require transmission of electricity, the additional revenue from sale of RECs could help improve viability of standalone systems. In the usual scenario, it may not be economical to transmit electricity from such regions.

### *3. Competition in the Electricity Market*

Separating RECs from electrical energy allows near cost-effective renewable energy to participate in the power exchange in a competitive manner. Revenue from RECs may be helpful to address the cost disadvantage for such renewable energy technologies.

### 4. Overcoming the Barrier of Natural Diversity

Renewable purchase obligation limits participation to the obligated entities, the distribution licensees in the Indian context. Additional cost due to such obligation is effectively allocated to all consumers in the area of a distribution licensee. Environmentally concerned consumers may be willing to consume higher proportion of green electricity. Such consumers can purchase RECs.

Tradability of RECs would allow wider participation by NGOs, development agencies, as well as the corporate sector that may purchase RECs as a part of their social corporate responsibility under the New Company Act 2013, Section 135, Schedule VII (ensuring environment sustainability).

### 5. Alternative to Meet Renewable Purchase Obligation

National-level tradability of RECs would allow obligated entities/distribution licensees to fulfil their obligation despite natural diversity. RECs may be purchased from generators located in other states. Limited resource endowments in a particular state may only permit lower renewable obligation.

### 6. Attract Investment

The REC market would provide appropriate opportunities for development of renewable-energy-based electricity generation. Through unbundling of RECs from electrical energy, the latter can also effectively participate in a competitively traded market for electricity. This would also allow investors in renewable energy technologies to hedge electricity price risk through electricity futures. This, in combination with RECs, would provide adequate risk hedging and, hence, encourage investment in renewable energy.

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| 4 | **Explain retail market of power market.** |

### 11.7.4 Retail Market

A retail electricity (see Section 6.1) market exists when end-use consumers can choose their supplier from competing electricity retailers. A separate issue for electricity markets is whether or not consumers face real-time pricing (prices based on the variable wholesale price) or a price that is set in some other way, such as average annual costs. In many markets, consumers do not pay based on the real-time price, and, hence, have no incentive to reduce demand at times of high (wholesale) prices or to shift their demand to other periods. Demand response may use pricing mechanisms or technical solutions to reduce peak demand.

Generally, electricity retail reform follows from electricity wholesale reform. However, it is possible to have a single electricity-generation company and still have retail competition. If a wholesale price can be established at a node on the transmission grid and the electricity quantities at that node can be reconciled, competition for retail customers within the distribution system beyond the node is possible.

Although market structures vary, there are some common functions that an electricity retailer has to be able to perform, or enter into a contract for, in order to compete effectively. Failure or incompetence in the execution of one or more of the following has led to some dramatic financial disasters:

1. Billing
2. Credit control
3. Consumer management via an efficient call centre
4. Distribution use-of-system contract
5. Reconciliation agreement
6. "Pool" or "spot market" purchase agreement
7. Hedge contracts—contracts for differences to manage "spot-price" risk

Competitive retail needs open access to distribution and transmission wires. This, in turn, requires that prices must be set for both these services. They must also provide appropriate returns to the owners of the wires and encourage efficient location of power plants. Independent companies should provide distribution and transmission services. This solves the cherry-picking problem which is a major concern of distribution utilities selling retail services and the ability to institute cross-subsidies, also a major concern of pure retail companies' schemes using two transportation prices. There are two types of fees, the access fee and the regular fee. The *access fee* covers the cost of having and accessing the network of wires available, or the right to use the existing transmission and distribution network. The *regular fee* reflects the marginal cost of transferring electricity through the existing network of wires.

transferring electricity through the existing network of wires.

Electricity consumers have the freedom to choose from a range of electricity contracts, e.g., long-term contracts with a fixed price, or a combination of spot-indexed price. Large consumers can also hedge with financial contracts. In theory, competition in the retail market can motivate low prices as well as the development of products (e.g., different forms of payment conditions, customer services, billing, and product bundles) for all end-users. However, to date, this development has not been realised and the majority of end-users have stayed with their historical supplier.



A retail electricity market exists when end-use consumers can choose their supplier from competing electricity retailers; Demand response may use pricing mechanisms or technical solutions to reduce peak demand.

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## 8.4 Energy Efficiency

*Energy-efficiency programmes should be considered as one of the resources during the planning stage* (see Fig. 8.3). Energy efficiency is the least expensive course of action, as the power industry can take given the current economic and environment situation [13]. Energy-efficiency savings (kWh) made are equal to a capacity of 1.3 times kWh of the generation plant.

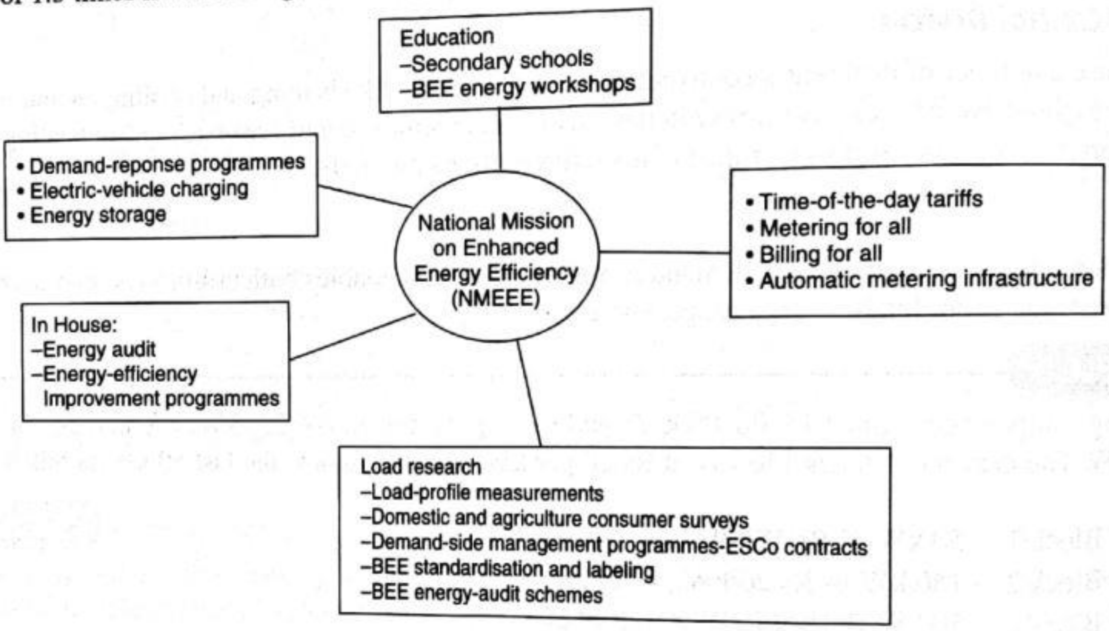


**Fig. 8.3** *Energy-efficiency programmes*

The ISO 50001 International Standard for energy management enables power utilities to establish the systems and processes necessary to improve energy performance, including energy efficiency, use, and consumption. Implementation of this standard is intended to lead to reductions in greenhouse-gas emissions, energy cost, and other related environmental impacts, through systematic management of energy. This international standard is based on the Plan-Do-Check-Act continual improvement framework and incorporates energy management into everyday organisational practices. Thus, energy-efficiency programmes offer huge potential for both lowering system-wide electricity costs and reducing consumers' electricity bills. There is large scope to reduce transmission and distribution losses to optimum value. As per the Energy Conservation Act 2001, the Bureau of Energy Efficiency [2] has been set up to estimate the energy-conservation DSM potential estimates along with cost estimates for planning purposes of the National Electricity Plan. Conservation and efficiency improvements will contribute to demand reduction and parenthetically reduce the need for new generation and system capacity additions. The National Power Policy dictates that energy conservation and demand-side management (DSM) are to be accorded high priority. The Central Government has already created the National Mission for Enhanced Energy Efficiency (NMEEE).

The Ministry of Power (MoP) and BEE were entrusted with the task of preparing the implementation plan for this Mission. The role of energy-services companies (ESCOs) will be enlarged. The report of the National Development Council Committee on Power has indicated the potential for energy conservation as follows [16]:

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| Industrial | 20% |
| Agriculture | 30% |
| Domestic and Commercial | 20% |

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| **6** | **Explain about security requirement and Disaster management.** |

## 7.11 Security Requirement

The security levels differ from utility to utility depending upon the policy of quality of supply. In order to ensure proper quality and continuity of power supply to consumers, power-system security requirements broadly fall under three stages:

1. Power-system planning
2. Power-system operating planning
3. Power-system control

At the planning stage, i.e., reinforcements/ expansions for utilities need long-term studies of the system requirements in terms of the following:

1. Analysis of demand and energy forecasts/past power cuts during peak/off-peak conditions. The system must be strengthened to meet the peak of agriculture load and other rural loads. The annual load-duration curve is drawn from the data of daily average power peaks collected for the year. From this curve, the energy-not-supplied ratio can be found.
2. Reserve margin planning in generation and transmission.
3. Protection system design to ensure fault clearance. This is an aspect of short-term planning.
4. Automated capability for system segregation—division and restoration.
5. Fast-acting load-shedding system which should be based not only on frequency but also on other system-operating conditions.
6. Reinforcements of reactive power devices (capacitors, etc.) wherever required.
7. Interconnected power system planning
   a) evaluation of power-exchange capabilities
   b) joint operating studies
   c) coordinated planning of facilities

Security concerns during short-term operational planning of a power system centres around provision of power cut or adequate operating reserve distributed over the area, and compliance of operating constraints in generation scheduling, maintenance scheduling programmes, etc. Apart from these preventive measures in short-term analysis, it is necessary to monitor the health of a power system before and during actual operation to see the adequacy of the power system. Security analysis and control at this stage and during power-system control requires security monitoring.

## 7.12 Disaster Management

Disasters occur as Natural Calamities (earthquakes, flood, storms etc.) and human acts (terrorist attack, sabotage etc.). A culture of preparedness and prevention require planning. Prevention may be building better standards, creating warning system for floods or storms etc., making risk insurance. Planning involves:

1. Disaster-management groups should be constituted at the power-utility level.
2. Control rooms shall have a list of minimum manpower required for continuous operation and maintenance of a particular utility on 24-hour basis with 2- or 3-shift operations. A complete list of personnel/experts for operation and maintenance of the utilities shall be maintained so that in case of emergency, the experts may be sent for quick fault finding and restoration of power supply.
3. Availability of all the resources meant for tackling the disaster/restoration process should be listed and the same should be available to the concerned members.
4. Alternate feedpoints should be identified for traction, defence locations, and other important areas.
5. The power back-up facilities like DG sets and inverters should be maintained properly and checked periodically for readiness of operation in case of any emergency.
6. The transportation arrangements in case of any emergency should be decided in advance.
7. Spares available with various power utilities and their locations should be identified so that these could be pressed into service within the shortest possible time.