CMR INSTITUTE OF TECHNOLOGY	USN		
Internal Assesment Test –III			
Sub:	Power System Planning	Code:	18EE824

Date:	11/05/24	Duration:	90 mins	Max Marks:	50	Sem:	8th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	Explain the benefits of deregulation.	[10]	CO6	L2
2	Explain reliability planning.	[10]	CO6	L2
3	Mention the adequacy indices in Distribution system Reliability Evaluation.	[10]	CO6	L2
4	Explain the need for power system studies.	[10]	CO6	L2

CMR INSTITUTE OF TECHNOLOGY	USN		
Internal Assesment Test –III			
Sub:	Power System Planning	Code:	18EE824

Date:	11/05/24	Duration:	90 mins	Max Marks:	50	Sem:	8th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	Explain the benefits of deregulation.	[10]	CO6	L2
2	Explain reliability planning.	[10]	CO6	L2
3	Mention the adequacy indices in Distribution system Reliability Evaluation.	[10]	CO6	L2
4	Explain the need for power system studies.	[10]	CO6	L2

5	Illustrate the concept of reliability by citing a suitable reliability model.	[10]	CO6	L2
6	Enumerate the demand response programme.	[10]	CO6	L2
7	Enumerate the principle of Electricity market. Explain system load.	[10]	CO6	L2

CCI HOD/EEE

5	Illustrate the concept of reliability by citing a suitable reliability model.	[10]	CO6	L2
6	Enumerate the demand response programme.	[10]	CO6	L2
7	Enumerate the principle of Electricity market. Explain system load.	[10]	CO6	L2

CCI HOD/EEE

Solution

1

The National Power Policy emphasises high-voltage distribution system as an effective [illegible] reduction of technical losses, prevention of theft, improved voltage profile, and better consumer service. Micro grids are required for isolated villages and urban centres. As per the Electricity Act 2003, electric utilities have moved towards unbundled model of generation companies (GENCOs), transmission companies (TRANSCOs), distribution companies (DISCOs), energy-service companies (ESCOs), and electricity franchisees. The franchisee model has been a path-breaking experiment in major cities and rural areas, and needs large expansion. As per the Electricity Act 2003, more than one distribution company can be allowed in a single area with its own distribution network. As per Section 42 of the Electricity Act, open access growth, segregating carriage 'distribution network' from content 'electricity supply business' will soon be in the operative stage with enactment of the Electricity (Amendment) Bill 2014. One major reason why open access has not been able to take off in India can be traced back to the fact that distribution companies in India manage businesses of two different natures—wire business and retail business. The wire business, by nature, is a monopolistic and regulated-return-earning business. Retail supply, on the other hand, is more conducive to providing consumer choice in the form of multiple suppliers, as it involves purchase of electricity in bulk from generators and selling it to consumers, apart from customer services, billing, and collection of charges from consumers. In a market structure, wherein the wire business as well as retail business is handled by a single distribution company, conflict of interest makes the distribution company wary of losing its retail segment to competition. Hence, the scope for introducing open access and retail competition is limited in this scenario. To overcome this issue, it is pertinent to segregate the wire and retail businesses. In such a market, all wire businesses will serve as common carriers and will be paid a reasonable regulated rate of return on

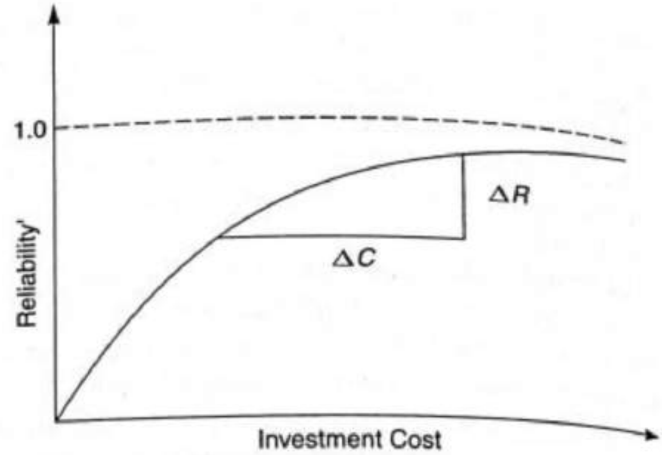
their investments. The retail business could be made open to multiple companies operating in the same area, with end consumers having the choice to choose their retailers based on price and service quality. Retail competition is expected to enhance operational and cost-efficiencies, and give the end consumer more choice. Cost-efficiency is achieved as competitors try to reduce input costs, and operational efficiency is focused upon as performance becomes a major criterion for consumers exercising their choice amongst various suppliers. Competitive power retailers would buy electricity from generators or in the wholesale market and package it to meet varied consumer demands. Their commercial viability would depend on their ability to meet consumer preferences and, in the face of competition, this is expected to result in lower retail prices (as competitive suppliers cut margins) and greater effort by competing retailers on increasing efficiency and consumer welfare. A consumer in Rajasthan wanting his power from Delhi will have to pay wheeling charges across two states, cross-subsidisation charges, as applicable.

2.

To increase consumers' willingness to pay for a greater level of reliability, there are two ways: provide more redundancy of supply to one consumer than to another. In the event of a disturbance or insufficient capacity, disconnect or interrupt the consumer who doesn't pay a premium rate for electricity.

However, there is an emerging recognition that the traditional practice of providing all users with a uniform and a good level of service reliability and power quality merits a re-examination. Given the changes in the electric utility industry's cost structure in recent years, there is a growing feeling that investments related to the provision of electric service reliability/quality should be more explicitly evaluated as regards to their cost and benefit implications. Cost–benefit analysis provides the basis for answering the fundamental economic question in reliability/quality planning: How much reliability is adequate? A key related question is how and where should a utility spend its "reliability rupees." Reliability levels are inter-dependent with economics, since more investment is necessary to increase reliability or even maintain it at current and acceptable levels.

This concept creates the incremental reliability characteristics as shown in Fig. 7.2.



(a)

Fig. 7.2 *Reliability versus cost*

Because of the changes in technology, consumer needs and lifestyles, economic factors, etc., reliability preferences can also shift over time. This may require periodically revising the reliability standards. Indeed, many consumer segments and end-uses today require substantially higher standards of service than were called for historically. Thus, reliability planning can be greatly enhanced if a mechanism can be initiated to measure consumer preferences for reliability, monitor major shifts in these needs, and use such information to appropriately revise the standards periodically if conditions so warrant.

In contrast, the total-cost-minimisation approach seeks to establish the trade-off that is conceptually depicted in Fig. 7.3.

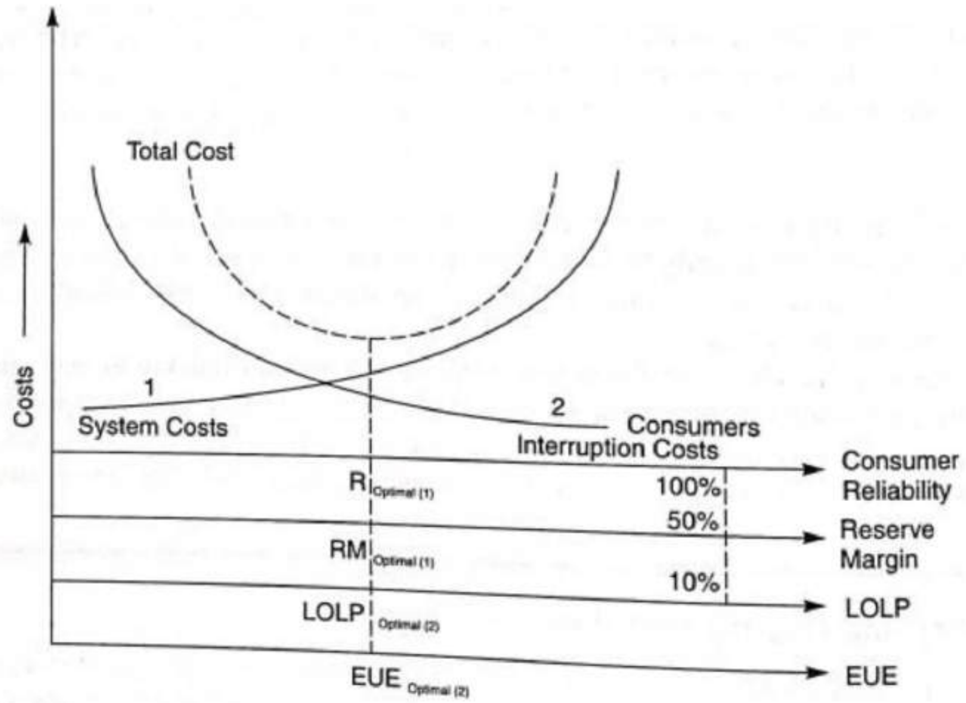


Fig. 7.3 *Optimum reliability*

The total cost of supplying electricity is the sum of system cost and consumer outage costs. The lowest point on the total-cost curve defines the optimal balancing of system costs and consumer costs, and determines the optimal reliability level.

From an implementation standpoint, the following analysis is required under this method. For each of several preselected reserve margins, an optimum resource mix is first determined. Next, for each such resource mix, production costing, revenue requirements, and reliability calculations are performed to estimate total costs as (revenue requirements) + expected energy not supplied (EENS) (outage cost in Rs/kWh). The lowest point on this curve defines the optimum reserve requirement which can also be calibrated to an optimal EUE (expected unserved energy) standard or some normalisation of EENS such as Loss-Of-Energy Probability (LOEP). Especially in situations where the present generation fuel mix is non-optimal, the total-cost-minimisation approach will indicate a higher reliability level because some generating plants will be added to reduce fuel costs.

7.7 Distribution Reliability

Distribution system fault immediately affect the consumer. Distribution systems account for up to 90% of all consumer reliability problems. Key to improving supply reliability and quality is better design (e.g., 11 kV line on suspension disc insulators is more reliable than on pin insulators) and better maintenance (e.g., diagnostic maintenance). IEEE Standard 1366–2003 provides definitions for the most important indices used to characterise reliability. Standard recommends a statistical approach for categorising major events that result in much more uniformity in reporting reliability indices if it was adopted. Because reliability levels vary from site to site around the system and vary from year-to-year to a variety of factors, it is reasonable to try and represent the expected performance using probabilistic methods rather than with simple indices. The probabilistic characterisation can help in understanding the *uncertainty* and the *variability* inherent in reliability indices. Distribution indices for reliability are SAIDI, SAIFI, CAIDI, ASAI, MAIFI. Distribution automation improves reliability.

1. *System Average Interruption Duration Index (SAIDI)* is the average total duration of interruptions of supply per annum that a consumer experiences in the period.
2. *System Average Interruption Frequency Index (SAIFI)* is the average number of interruptions of supply in the year for consumers who experiences interruption of supply in the period.
3. *Consumer Average Interruption Duration Index (CAIDI)* is the average duration of an interruption of

supply in the year for consumers who experience interruption of supply in the period.

4. *MAIFI* is the average number of momentary interruptions that a consumer would experience during a given period (typically a year). Electric power utilities may define momentary interruptions differently, with some considering a momentary interruption to be an outage of less than 1 minute in duration while others may consider a momentary interruption to be an outage of less than 5 minutes in duration. MAIFI is calculated as

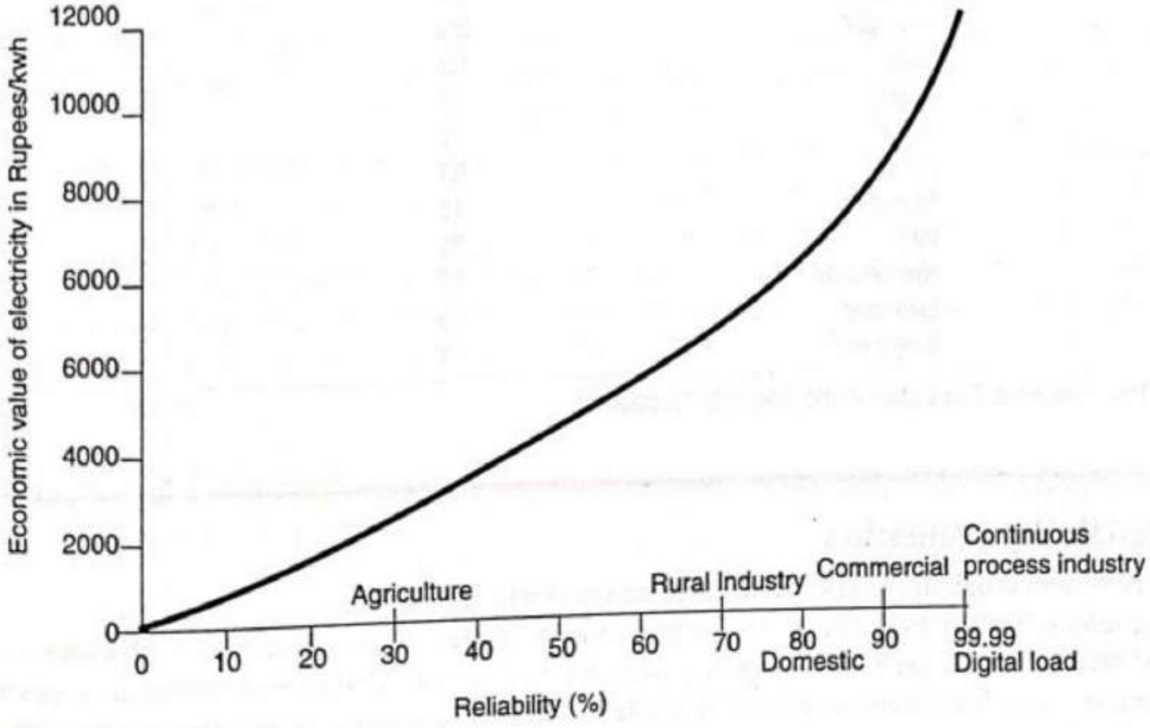
$$\text{MAIFI} = \frac{\text{Total number of consumers interrupted less than defined time}}{\text{Total number of consumers served}}$$

However, MAIFI is useful for tracking momentary power outages, or "blinks", that can be hidden or misrepresented by an overall outage duration index like SAIDI or SAIFI. Momentary power outages are often caused by transient faults, such as lightning strikes or vegetation contacting a power line, and many utilities use reclosers to automatically restore power quickly after a transient fault has cleared. As per IEEE Standard 1366–2000, momentary interruption is considered between 3 seconds and 5 minutes duration.

ASAI (Average Service Availability Index) is

$$= \frac{\text{Consumer hours service availability}}{\text{Consumer hours service demand}}$$

Analysis of consumer failure statistics has indicated that the distribution system makes about 90% contribution to overall consumer supply unavailability and the bulk power system contributes only a relatively small component to the overall HLIII consumer indices. A typical illustration of this effect is shown in Fig. 7.4 for a metropolitan city. The ability to perform HLIII adequacy evaluation will provide the planner with an enhanced ability to quantitatively assess the merits of various available reinforcement options and ensure that the available but limited capital resources are used to achieve the optimum incremental reliability and improvement in the system. Another demanding part or reliability is deducing the outage costs for different types of consumers in terms of Rs/kW or Rs/kWh not supplied. Typical economic values of reliability for different consumers are shown in Fig. 7.5. Value of Lost Load (VOLL) is used to evaluate the outage cost during cconsumer surveys for various categories of consumers. Distribution systems account for up to 90% of all consumer reliability problems. The key to improving supply reliability and quality is better design (e.g., 11 kV line on suspension disc insulators is more reliable than on pin insulators) and better maintenance (e.g., diagnostic maintenance) [1, 20].



Typical economic values of reliability for different types of consumers

4.

"A power systems study is made up of various engineering analysis investigations. The goal of each study is to have a safe, efficient and reliable power system for your facility under both normal and abnormal conditions."

In order to perform Power systems studies, design engineers and power systems engineers are required who must have a high degree of understanding on proper application as well as a depth of understanding on power systems.

A power system comprises of the various subsystems that include generation, transmission, and distribution. The goals of power system analysis are the following:

- To model or to execute per phase analysis of power system components
- To monitor the voltage at different buses, real and reactive power flow between buses
- To plan future expansion of the current system
- To analyze the system under different fault conditions and based on different Scenarios
- To design the Protective Devices, as well as to investigate the ability of the system to handle small and large disturbances or faults of any kind.

5. Reliability is a measure of a system's ability to perform its intended function without failure over a specified period under given conditions. It is crucial in various fields such as engineering, manufacturing, and software development, where the consistent and dependable performance of a product or system is essential.

Example of a Reliability Model:

The Exponential Reliability Model

The Exponential Reliability Model is one of the simplest and most widely used models in reliability engineering. It assumes that the time between failures of a system or component follows an exponential distribution. This model is particularly useful for electronic components and systems where the failure rate is constant over time.

Key Concepts in the Exponential Reliability Model:

Failure Rate (lambda):The failure rate is the rate at which a system or component fails. It is typically expressed as failures per unit of time (e.g., failures per hour). In the exponential model, \(\lambda\) is constant, meaning the probability of failure is the same at any point in time.
Interpretation:
The exponential reliability model shows that the reliability decreases over time but does so in a predictable way, assuming the failure rate is constant. This model helps in making informed decisions about maintenance schedules, warranty periods, and design improvements to enhance reliability.
6.

8.1 Demand Response (DR)

DR should be considered one of the resources during the planning stage. Demand Response Planning (DRP) can be defined as a programme established to motivate changes in electric use by end-use consumers in response to changes in the price of electricity over time, or to give incentive payments designed to induce lower electricity use at times of high market prices or when grid reliability is jeopardised (see Fig. 8.1). Regulatory framework also needs to be in place for implementation of demand-response strategies. Consumer awareness and maintaining transparency with them must be a priority to win their confidence and ensure acceptance of the demand-response programmes. The electrical distribution network must be strengthened to ensure reliability in operations. Common examples of demand response include ability of the industry to change their production patterns, without suffering a loss of revenue and jeopardising economy of overall operations, such that the electricity consumption can be reduced during hours of need of the grid. DR can be used to relieve congestion or overload condition on the distribution network. DR can be applied to support consumers fed from a particular distribution node by relieving overload on a feeder of the distribution system without incurring the cost of dispatching a DR event across a whole transmission area. DR is a vital improvement against load-shedding practice adopted currently to reduce the excessive power demand in India.

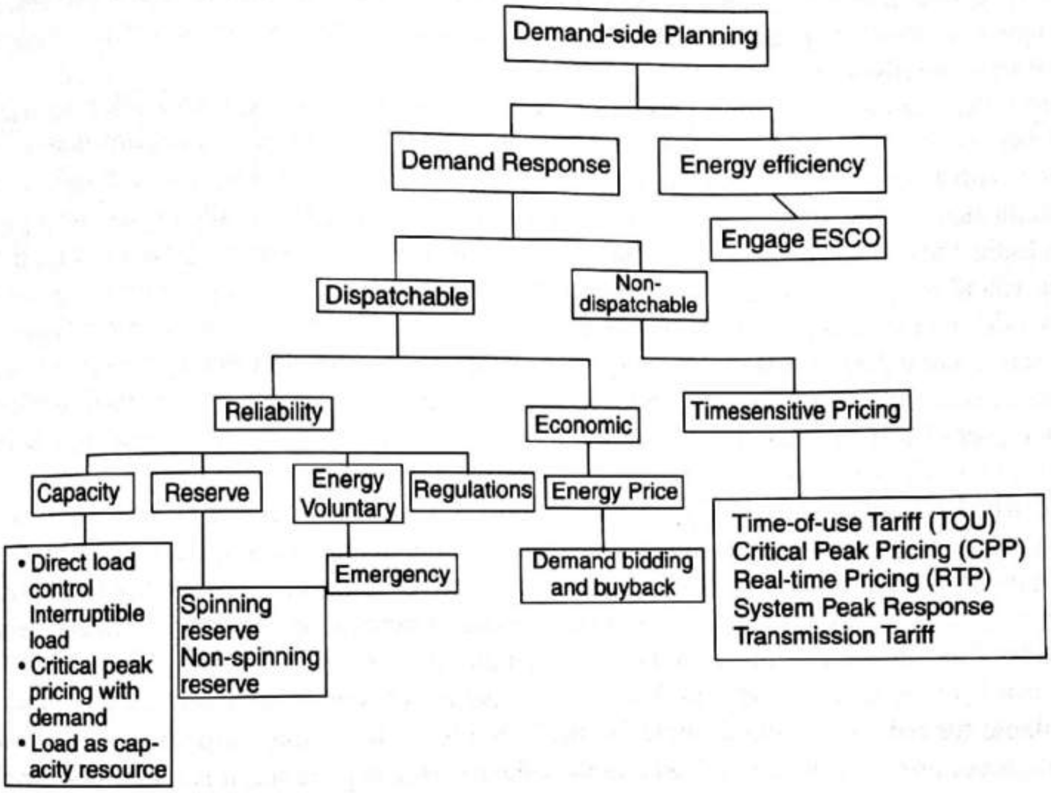


Fig. 8.1 *Demand-response planning*

7.

2.2 System load

- Total electric power consumed by connected users + losses in all parts of network
- Coincidence factor
- Power → active +reactive
- System load is divided into
  - Motive load
  - Heating load
  - lighting load
  - system losses

11.1 Market Principles

The principles for the electricity market are the following:

1. The market's mission is growth.
2. Electricity is, by its nature, difficult to store and has to be available on demand. Demand and supply vary continuously.
3. Electricity is a commodity with a highly seasonal, inelastic demand. This, combined with weather-dependent generation and demand, is prone to short-term price volatility.
4. In theory, electricity markets provide generators with incentives to reduce costs and increase productivity and thereby induce expectations of lower electricity prices to consumers. Electricity markets, however, also send strong price signals in times of scarcity. This leads to periods with price peaks and, in situations with abundant supply, very low prices.
5. Electricity does not behave like a normal commodity. If the price of red apples is high, you buy green apples; but what do you do about electricity? You cannot live in society without it. It is essential to everyone's daily life—whether you are at work or at home. There is no substitute for it.
6. Electricity flows from the power plant to the consumer at 200, 000 km/second. Some power plants must constantly change their output.

7. The most fundamental difference is that electrical energy is inextricably linked with a physical power system that functions much faster than any market, requiring generation (supply) and load (demand) balancing on a second-by-second basis.
8. The power market operates on the basis of long-term, short-term, day-ahead, or intra-day commitments.
9. The main feature of price formation in wholesale spot markets is the instantaneous nature of electricity. The physical laws that determine the power delivery across a grid requires synchronised energy balance between injection of power at generating points and offtake at demand points (plus some allowance for transmission losses).
10. A significant difference between electrical energy and other commodities is that energy produced by one generator in the power system cannot be directed to supply a specific consumer; rather, the energy is pooled.
11. The laws of physics determine how electricity flows through an electricity network. Hence, the extent of electricity lost in transmission and the level of congestion on any particular branch of the network will influence the economic dispatch of the generation units.
12. Markets bring efficiency in usage of transmission capacity by economic dispatch and congestion management.
13. Markets encourage investment signals to investors in generation and transmission.
14. There are daily and weekly cyclical variations in cost and price of electrical energy.
15. Marginal cost varies over the course of the day.
16. Electricity is the only network with prices that change every 15 or 30 minutes.
17. There is often shortage of markets in India. Fixing of trading margins by regulators is generally defined.
18. Peaking power must be made viable by applying time-of-the-day tariffs.
19. There is, therefore, a physical requirement (as per the Electricity Act 2003, sections 26–34) for an independent transmission system operator to coordinate the dispatch of generating units to meet the expected demand of the system across the transmission grid.