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Internal Assesment Test –III

Sub:	Power System Planning							Code:	18EE824
Date:	13/05/23	Duration:	90 mins	Max Marks:	50	Sem:	8th	Branch :	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	With a relevant block diagram explain the importance of energy efficiency programme.	[10]	CO6	L2
2	Write short note on i) Smart Power Market ii) Power pool	[10]	CO6	L2
3	Explain reliability evaluation.	[10]	CO6	L2
4	Explain the benefits of deregulation.	[10]	CO6	L2

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4	Explain the benefits of deregulation.	[10]	CO6	L2

5	Explain reliability planning.	[10]	CO6	L2
6	Mention the adequacy indices in Distribution system Reliability Evaluation.	[10]	CO6	L2
7	Explain the need for power system studies.	[10]	CO6	L2

CCI HOD/EEE

5	Explain reliability planning.	[10]	CO6	L2
6	Mention the adequacy indices in Distribution system Reliability Evaluation.	[10]	CO6	L2
7	Explain the need for power system studies.	[10]	CO6	L2

CCI HOD/EEE

Q.1

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.

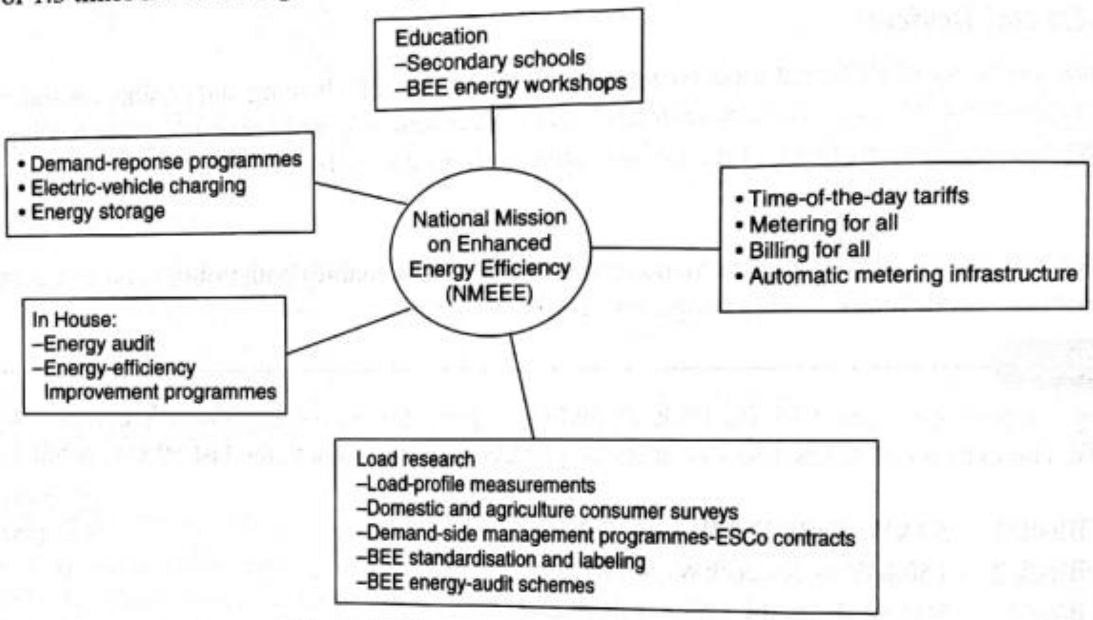

Fig. 8.3 *Energy-efficiency programmes*

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]:

Industrial	20%
Agriculture	30%
Domestic and Commercial	20%

Q.2
i)

11.2 Power Pool

The Indian power market is a *power-pool* model. The power-pool model envisages different generators selling to a pool and distributors, power exchanges, traders, and large consumers buying from it. The pool functions as a marketplace for trading. These pools are designed to maximise competition in generation; compete on price, not cost; and remain open to all market participants. Pools deal in spot and real-time trading. The pool operation also transacts bilateral contracts. A number of power exchanges in the country mean a number of power pools. An electricity pool is not a physical location; rather, it is a set of rules and procedures managed by the load-dispatch centre as per the grid code. The power pool operates the power exchange wholesale market under mandatory trading arrangement, bidding, and settlement procedures. It is not possible to distinguish which generator produces the electricity consumed by a particular consumer. Hence, this is the concept of a central pool of generation to supply total consumer demand. Typically, pool rules require generating and supply companies to submit day-ahead bid packages and demand reservations for each half-hour period during the next day or 7 days. The power-exchange administration uses this to prepare a seven-day generating unit commitment plan, ranking bids in merit order to determine the system marginal price at which offers match demand. The pool price paid to generating companies generally comprises

1. The system marginal cost
2. Start-up and no-load adjustment
3. Ancillary services payment black-start capability and spinning reserve

ii)

11.7 Power Markets [14]

11.7.1 Power-Exchange Market

The power-exchange market is a market where buyers, sellers, electricity traders, open-access consumers, and members of power exchange transact on standardised contracts. Here, the power exchange, or clearing corporation, is a counter-party to such contracts and, further, scheduling is done by regional load dispatch centres or the National Load Dispatch Centre. The norms are applicable to all contracts (intraday contract/contingency, day-ahead contract, term-ahead contract) contract transacted on power exchanges, other exchanges and also bilaterally, that is, Over-The-Counter (OTC) market. The norms require a Clearing Corporation (CC) for setting up a power exchange. There are, at present, three power exchanges approved by CERC as given below:

1. The Indian Energy Exchange (IEX)
2. Power Exchange India Limited (PXIL)
3. National Power Exchange Limited (NPEL)

The Exchange is on the pattern of the National Stock Exchange. This is a company that has entered into a Memorandum of Understanding (MoU) with a number of power producers, who commit the surplus power, and power-deficit entities looking for power. The Act provides that the appropriate commission may fix the trading margin, if considered necessary. The regulator role needs to be largely confined to monitoring to prevent collusion and unfair gaming.

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The price in the Day-Ahead Market (DAM) is, in principle, determined by matching offers from generators to bids from consumers/power utilities/exchange members at each node to develop a classic supply and demand equilibrium price, usually on an hourly interval for 24 hours, and is calculated separately for sub-regions in which the grid/system operator's load-flow model indicates that constraints will bind transmission. Exchange members participate in trade, the day before, standard hourly contracts. Hourly contracts provide considerable flexibility by allowing operators to fine-tune over the delivery day (purchase addition or sell excess). Power exchanges have the following characteristics:

1. Standardized contract structure
2. Robust clearing and settlement system
3. Risk management
4. Transparent price-discovery mechanism

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). Typical energy products during 24 hours can be as shown in Fig. 11.4.

1. Base load
2. Peaking load
3. Super peak load

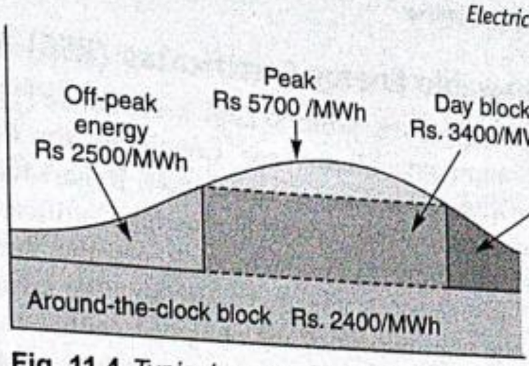


Fig. 11.4 *Typical energy products in the market throughout 24 hours*

The spot market is operated by power exchanges. Prices in the spot market fluctuate extensively depending on demand-supply dynamics in the market. It is the market where physical delivery of electricity occurs either on the same day as the date of transaction (T) or on the next day ($T + 1$). The day-ahead market (DAM) is used for trading hourly contract, one day prior to the delivery of electricity. Both buyers and sellers electronically submit their anonymous bid during the bid-call session. The optimisation algorithm for the day-ahead power market crunches every buy and sell bid submitted. The market clearing price is determined on the basis of the intersection point of the demand-and-supply curve. This uniform price (MCP) is offered to both selected buyers and sellers. Price discovery in the DAM market is a true function of demand and supply only. Area-wise prices are marked for sale.

Q.3

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.

Q.4

The National Power Policy emphasises high-voltage distribution system as an effective method for 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.

Q.5

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.

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.

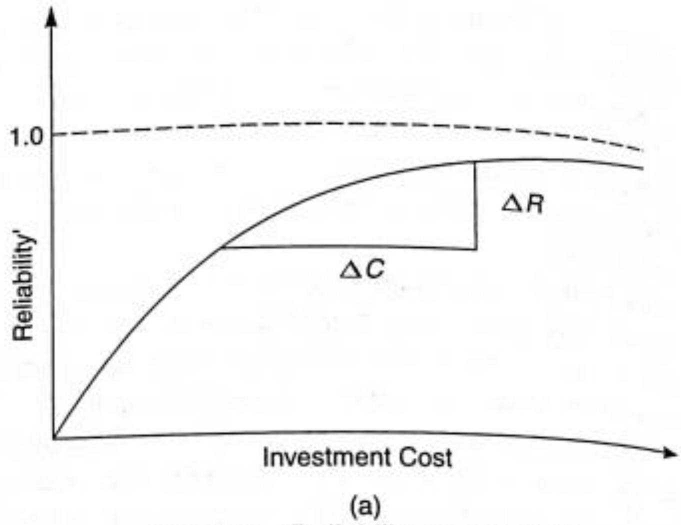


Fig. 7.2 *Reliability versus cost*

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

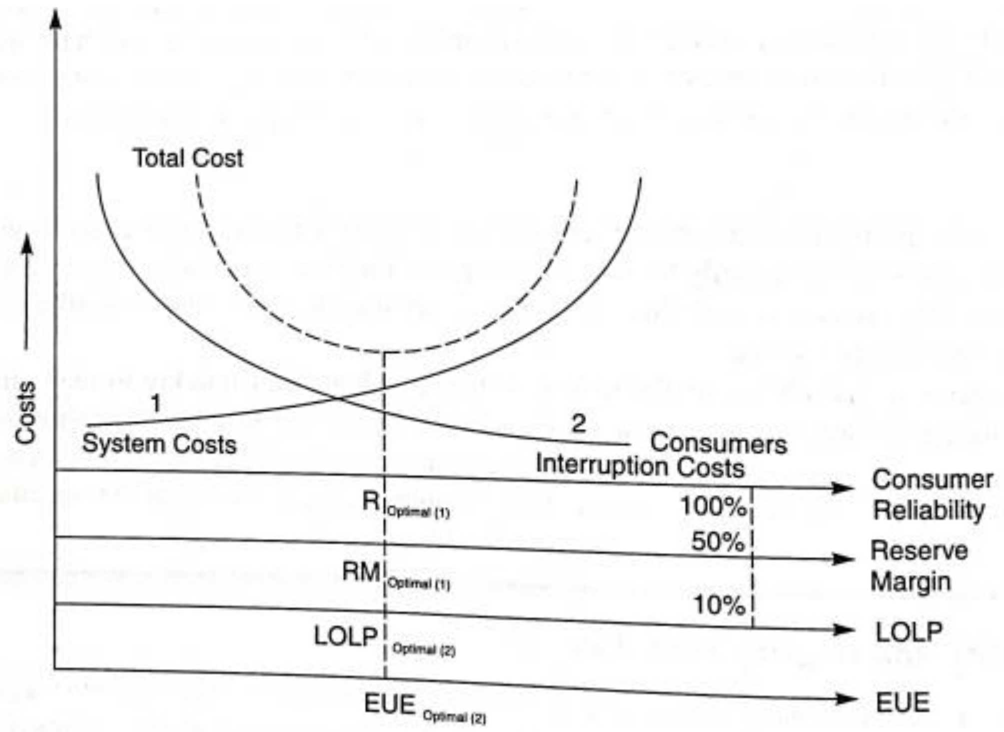


Fig. 7.3 *Optimum reliability*

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.

Q.6

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

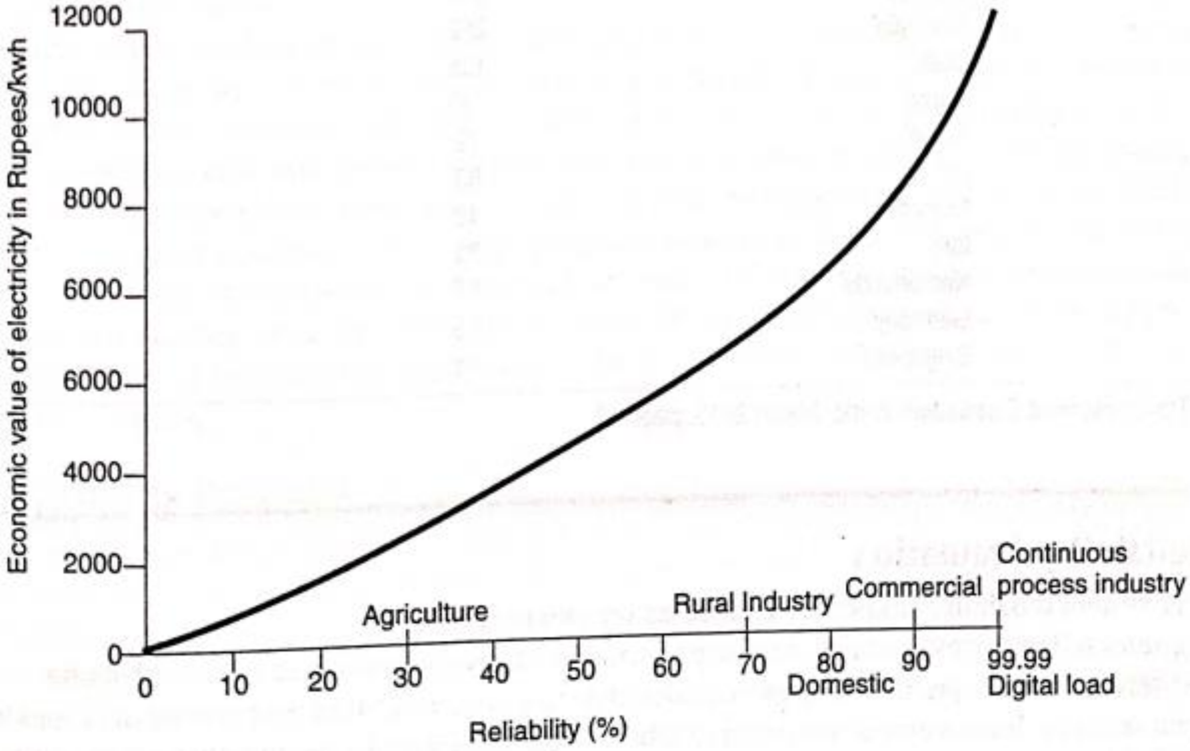
$$\text{MAIFI} = \frac{\text{Total number of consumers interrupted less than defined time}}{\text{Total number of consumers served}}$$

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

Q.7

"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.