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Internal Assesment Test - II

Sub:	POWER SYSTEM PLANNING							Code:	10EE761
Date:	07/ 11/ 2017	Duration:	90 mins	Max Marks:	50	Sem:	7th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1	Mention the need and benefits of rural electrification. Briefly explain the components of rural electrification.	[10]	CO3	L4
2	Explain private participation with respect to ownership options and modes of participation.	[10]	CO3	L4
3 (a)	What are objectives of sound pricing structure? Explain	[05]	CO3	L4
(b)	Discuss in brief rational tariff	[05]	CO3	L2
4	What are the resource of generation and absorption of reactive power in transmission and distribution lines? Compare advantages and disadvantages of any four compensating equipments.	[10]	CO5	L4
5	Explain need of insulation coordination in power system.	[10]	CO4	L4
6	Explain the terms 'non utility generation' & 'wheeling'. How wheeling affects system performance? How wheeling contracts are made?	[10]	CO4	L4
7	Describe the major environmental hazards caused by fossil fired thermal plants and the methods to minimize them.	[10]	CO4	L2

******All the Best*****

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Answer key

1ans:

RURAL ELECTRIFICATION(4.10 & 5.9)

- **Rural Electrification programme** is mainly **funded by Rural Electrification Corporation (REC)** of India since **1969.**
- It is for **all-round development** of **village life, agriculture and village industries**.
- **Rural electrification** concerns the **supply of electricity to low density areas of villages**.

आर ई सी
REC
असीमित ऊर्जा, अनन्त संभावनाएं
Endless energy. Infinite possibilities.

RURAL ELECTRIFICATION(4.10 & 5.9)

- It is traditionally **achieved in two ways**

1. By the **installation of generators independent of the grid** (**diesel** or **micro-hydel** or **wind generation**)

directly at the **consumption site** (village, farm, **small industry**, **dispersed dwellings**)

2. by the **extension of the interconnected electrical grid**.

- This latter technique accounts for 80 per cent of rural electricity distribution in the world and about **98 per cent in India.**

- rural areas are distinguished from urbanized areas as the **sites to be electrified** are often **several kilometres**.

- there is **lower population density**

- electricity **consumption is much lower** than the average urban consumption.

- Because the **great distance** of sites to be electrified ,**installation of MV lines** from the grid over sometimes significant distances. (**2 to 3 km** on an average in India)

- The **low population density** in comparison with **urban sites.**
- The rural electrification programme has a useful contribution to the agricultural production, especially by the energization of pump sets for irrigation.
- The rural power system has **long lines, low voltage, low power factor, overloaded transformers**
- It causes **damage to the costly equipment and higher T & D losses.**
- The **consumers** do not install **capacitors in their premises** to increase **power factor**
- have no inclination of participate in the **energy conservation**.

COMPONENTS OF RURAL ELECTRIFICATION PLANNING :

1. Village electrification:

- At present **millions of villages** have been electrified .
- **86 %** in the country
- A **village is deemed to be electrified** even **if a single connection** is given in the **revenue boundary of the village**.

2. Pump set energization :

- This is a **major scheme of rural electrification** planning.
- Rural Electrification Corporation of India**, NABARD** and **commercial banks** have **provided funds** in equal ratio for pump sets energization.

3. Load development :

- The **use of electricity** for **domestic** and **other non-farm activities** is still limited.
- **creation of HT network** in the rural areas for **industrial development** is **yet to take place.**

4. System improvement planning :

- The existing system has expanded at a fast rate and **not strengthened**.
- therefore, **making** the **overall system inadequate**.
- **Continuous system improvement** needs to be **planned** as part of the work culture.

5. Insulated aerial cable system :

- Insulated overhead distribution system , better for new work
- **retrofitting** of existing base system.
- **High Voltage ABC (Aerial Bunched Cable)** system is used in many countries.

- Covered conductor system provides an improved open wire system which can be less expensive than HV ABC.
- Two versions of power conductors, namely, covered conductor (CC) and covered conductor thick (CCT) are now used.

DECENTRALIZED GENERATION :

- electrification of these **villages** by conventional means from grid supply is becoming increasingly **expensive**
- It is desirable to **electrify the villages** through **decentralized generation** schemes like **mini-micro hydel**, solar, wind, geothermal etc.
- **growth of load** in already **electrified villages** can be **accelerated by** such **small generation schemes**.
- **small power generation schemes** ⇨ given subsidies up to **50 per cent** by the **Ministry of Non-conventional Energy Sources** to reduce the ultimate cost of supply

2ans:

PRIVATE PARTICIPATION (5.4):

- **Private power projects** are important as a part of **the country's investment resources**
- Under **the Indian Electricity (Supply) Act**, the **private sector generating companies, transmission or distribution companies are encouraged to participate in power sector.**
- Another **advantage of private' sector** participation

⇩

new work and **management skills**

⇩

timely execution of the project

⇩

quality in work and service

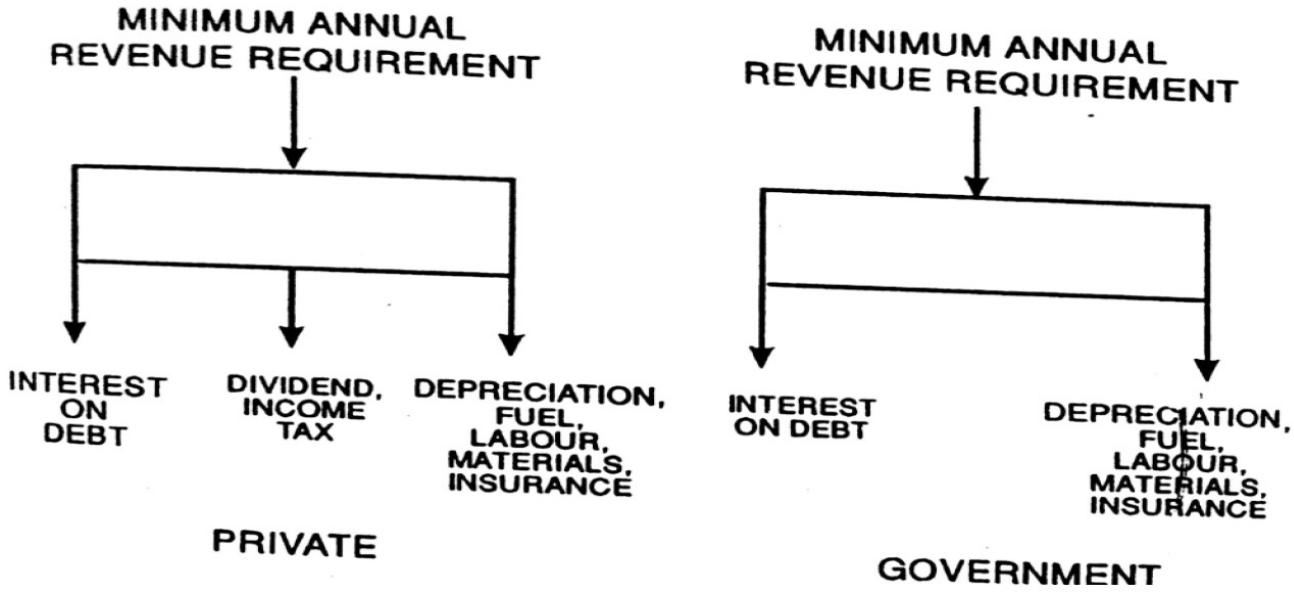
OWNERSHIP:

- **Power utilities** have a **natural monopoly**.
- The efforts are to **remove this monopoly** by creating **supply market** as in **UK , USA, Argentina, Australia.**
- The **consumers** will be **free to choose their suppliers**.
- **Rapid decision**-making, **risk-taking** and **innovation** are needed.
- **these qualities** are usually **lacking in state-owned undertakings.**
- **Privatization** will **restructure** the electricity **supply industry** in the near future.
- It will **break up vertically integrated monopolies** in search **of lower costs** and **higher productivities.**

- ## OWNERSHIP:

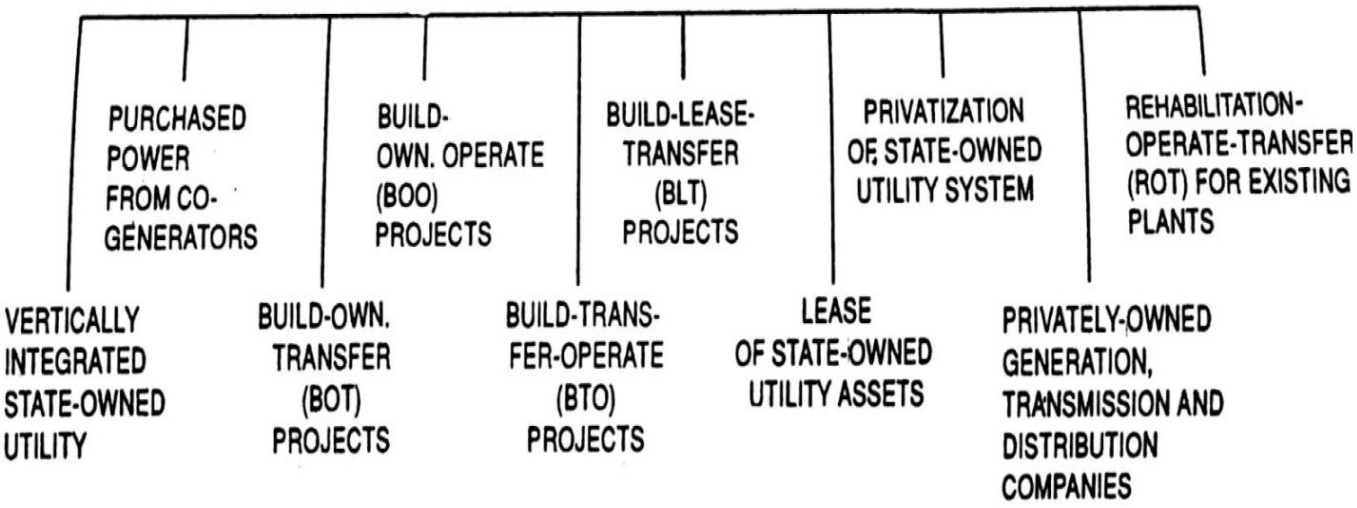
- The **public sector** and **private sector** power utilities have **different financial structures**
- Various **private sector options**
- **turnkey contract**, **BOOT**, **BOO,** BOL, ROL etc.
- **BOO (Build-own-operate)**
- **BOOT (Build-own-operate-transfer)**
- **ROL (Rehabilitate-operate-lease)** are **common for old plants**
- BOM (**Build-own-maintenance**) for **new transmission lines**.

OWNERSHIP:



- **Fig: showing the finance structure of private & public utilities.**

- **OWNERSHIP:**



- **Fig: ownership options of power utility**

- **Incentives given by the government to private investment are:**

1. Private sector units can set up **coal/lignite**/oil/gas-based thermal, hydel, wind and solar energy projects of any size.

2. a)Private enterprises can set up units, either as licensees

distributing power in a licensed area

own generation or purchased power

b)as generating companies, generating **power for supply to the grid**.

3. Licensee companies holding **license to supply and distribute** energy in a specified area under a license **issued by the state government** will function under a liberalized economic and legal environment.

4. **New licenses** can be issued by the **state governments** to **private units** willing to enter the electricity sector.

5. **Private enterprises** may be allowed to set up and they can **sell or distribute surplus power** to state electricity boards (**SEBs**).

6.Both licensees and generating companies can **enjoy** the following **Benefits**:

(i) Up to **100% foreign equity** participation can be **permitted for projects** set up by **foreign private investors**.

(ii) With the **approval of the government**, import of equipment for power project will be permitted.

(iii) Return for **producers**.

3ans: a)

3 MAIN OBJECTIVES OF SOUND PRICING STRUCTURE/CONSUMER TARIFF(5.13)

i. Financial:

have to ensure that revenue yielded from the application of tariff to consumer is sufficient.

ii. Economic:

ensure that tariff charged to the consumer enables them to make rational & optimal choice in the use of energy, discourage waste & promote efficient allocation of resources.

iii. Social:

ensure that price structure takes into account **fair distribution** of costs among **various classes** of consumers, **subsidization of target class** etc.

b)

2 BASIC TARIFF MAKING PHILOSOPHIES ARE RECOGNIZED:

I. COST BASED

II. MARKET BASED

- Factors used in developing this cost based tariff are capacity-related, energy-related & consumer related.
- They vary for different classes of consumers (residential, agricultural, commercial, industrial etc.)
- They require greater analysis to allocate costs.
- They are **generally preferred**
- Less likely to be criticized by consumer

- 2 approaches for costing ⟶ **average & marginal**
- Average supply cost uses historic data.
- Marginal cost is the cost for producing extra KWh or saving of one KWh from less generation.
  - SRMC (cost of Producing one more KWh from existing capacity)
  - LRMC (cost of producing one more KWh from new power plants)

LRMC >= SRMC

LONG RUN MARGINAL COST >= SHORT RUN MARGINAL COST

COST-BASED TARIFF:

- Tariff must be sufficient to raise **adequate revenue** to meet financial utility requirements.
- It should be based on **supply cost** for each category of consumer.
- Peak consumers should pay both **capacity & energy cost** whereas off-peak consumers should pay only energy cost.

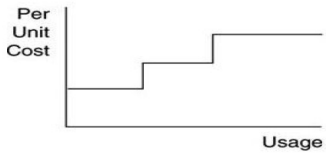
- Tariff must be based on **marginal cost** for serving demand:
  1. for different consumer categories
  2. For different seasonal industries (ice industries, rice shellar)
  3. for different **hours of day** (peak hours & off-peak hours)
  4. For different voltage levels (HT & LT consumers)
  5. For different **geographical** areas.

MARKET-BASED TARIFFS:

•Following are some examples of market based tariffs:

1. Certain industrial rate classes may be **subsidized** to attract new industry to an area.
2. **Residential rates** may be **subsidized** by other classes or social/political purposes such as single point service **(one lamp) for Harijan**
3. **Agricultural tube well services** may be **subsidized** to encourage increased production.
4. **Inverted block rates** have been used **to encourage energy conservation** depending upon **price elasticity (E_P)**

$(E_P) = \frac{\%\text{ change in energy consumption in KWhs}}{\%\text{ change in price per KWh}}$



INVERTED BLOCK RATE STRUCTURE
The cost per unit of consumption under an inverted block rate structure increases with additional units of consumption.

BESOM TARIFF

New BESCOM tariff for the Electricity Consumption

Category Description	Particulars	Existing Tariff as per Tariff Order-2016	Particulars	Approved as per Tariff Order 2017	Remarks
Domestic - Applicable to Areas under Bruhat Bangalore Mahangara Palike (BBMP),Municipal Corporations and all Urban Local Bodies	**Sanctioned Load Fixed Charge (FC)**		**Sanctioned Load Fixed Charge (FC)**		
	FC For Ist KW	Rs.30/-	FC For Ist KW	Rs.40	**Rs.10/- Increased**
	FC For addl. KW	Rs.40/-	FC For addl. KW	Rs.50	**Rs.10/- Increased**
	Consumption Energy Charges (EC)		**Consumption Energy Charges (EC)**		
	0 to 30 KWH	300 Ps	0 to 30 KWH	325 Ps	25 Paise Increased
	31 to 100 KWH	440 Ps	31 to 100 KWH	470 Ps	30 Paise Increased
	101 to 200 KWH	590 Ps	101 to 200 KWH	625 Ps	35 Paise Increased
	Above 200 KWH	690 Ps	201 to 300 KWH	730 Ps	40 Paise Increased
			301 to 400 KWH	735 Ps	45 Paise Increased
			401 to 500 KWH	740 Ps	50 Paise Increased
			Above 500 KWH	740 Ps	50 Paise Increased

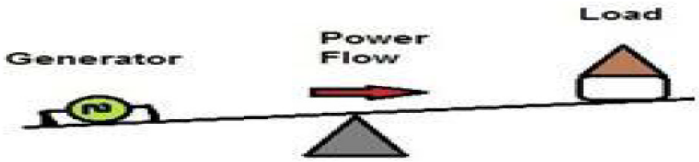
4ans:

REACTIVE COMPENSATION

Reactive power:

- electrical energy is generated, transmitted, distributed, and utilized as alternating current (AC).
- reactive power needs to be supplied along with active power.

Real power flow without reactive power support



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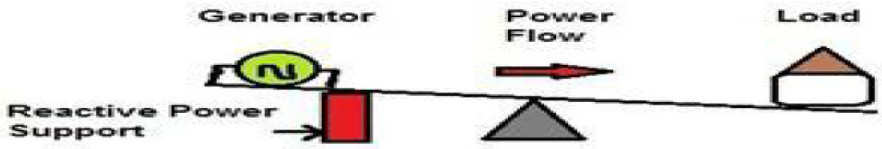


REACTIVE COMPENSATION

- Reactive Power can be leading or lagging.
- The active power that contributes to the energy consumed.
- reactive power does not contribute to the energy. Reactive power is an inherent part of the "total power".
- Reactive power is either generated or consumed in almost every component of the system.
- reactance can be either inductive or capacitive, which contribute to reactive power in the circuit.
- Most of the loads are inductive, and must be supplied with lagging reactive power.
- It is economical to **supply this reactive power closer to the load in the distribution system.**

DEFINITION:

- **reactive power compensation** (VAR) ➡ improve the performance of AC systems
- Any device which is connected in series or parallel with load which is capable of supplying reactive power demanded by the load is called **reactive power compensation device.**

- **2 aspects:**

a) **LOAD COMPENSATION:**

I. To increase power factor of the system

II. To balance real power drawn from the system

III. To compensate voltage regulations

IV. To eliminate harmonics

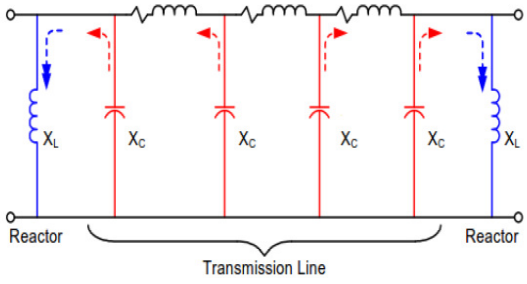
b) **VOLTAGE SUPPORT:**

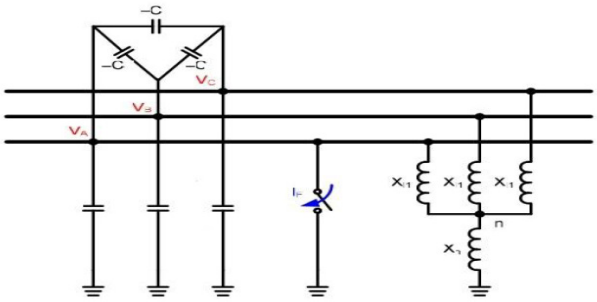
To decrease voltage fluctuation at a given terminal of transmission line.

- Due to line loading, reactive power balance of a line is affected.
- These variations if not compensated , will give rise to large voltage variations.

• Excessive over voltage • If line is lightly loaded/unloaded	• Large voltage drops • If the line is heavily loaded

- Shunt compensation ➡ shunt reactors





- Shunt reactors will effectively offset the excessive reactive power produced in the line.
- They limit power frequency, over voltage during light loads & relieve the system from reactive power absorption.
- Thus it improves voltage regulation & reduce losses in the system.
- For long term system planning , p.f at 220kV & Higher voltage substations are taken as 0.95lagging.
- But existing p.f varies between 0.7 to 0.85 lagging.
- This is mainly due to the use of oversized non-standard induction motors.
- This causes excessive withdrawal of reactive power by load from transmission lines (220,400kV).
- **SO REACTIVE COMPENSATION SHOULD BE PROVIDED IN LOWER VOLTAGE SYSTEMS TO MEET REACTIVE POWER REQ OF LOADS.**
- Shunt capacitors will provide reactive power to the load. They are installed on 11,33 or 66kV side.

Why capacitors?

- why capacitors are used as reactive power compensation device?
- A capacitor is said to be generator of reactive power. When a capacitor is connected across a load, it provides reactive power to the load.
- Dielectric materials make it possible to increase the output per unit and to reduce losses, thus making the compensation by means of capacitor more profitable.

Benefits of reactive power compensation:

1. Better efficiency & hence result in unloading of power generation transmission & distribution equipments.
2. Improvement in voltage profile.
3. Reduced KVA demand.
4. Higher load capability
5. Reduced system losses & hence power generation cost.
6. Effective management of reactive generation to provide stability margins both in peak load & off-peak loads

Other EQUIPMENTS:

- equipments for reactive power control are:

1. synchronous condenser
2. Capacitor banks
3. Series compensator
4. STATCOM
5. Shunt reactor
6. Static VAR Compensator

5ans:

INSULATION COORDINATION:

- was introduced to arrange the electrical **insulation levels** of different components in the electrical power system.
- Insulation strength of electrical apparatus is selected
  → voltage stress on the system
  & available protective devices in system
- Both **technical & economic aspects** are considered.
- Insulation strength of apparatus are determined by various **dielectric tests/ high pot test**.
- The strength of insulation for **lightning overvoltage** is checked by impulse test.

INSULATION COORDINATION:

- Overvoltage protection is established by two devices:

I. Spark gaps
II. Lighting arrestors
III. Surge diverters

- Insulation requirements of line dep on:

I. Elevation above sea level
II. Severity of lighting activity
III. Soil conditions
IV. Switching overvoltage
V. Pollution level to determine outage rate.

INSULATION COORDINATION:

- Bus insulation is given highest priority.

- As it is required to **maintain continuity of power.**
- CB, isolators , CT & PT are given next priority.
- These are **installed in stations near line terminations**.
- Transformer cost is sensitive to choice of insulation level.

6ans:

WHEELING: (9.6)

- "Wheeling" refers to the transfer of electrical power through transmission and distribution lines from one utility's service area to another's.
- Wheeling can occur between two adjacent utilities, or between utilities in different states
- excess power can be transmitted to other utilities with too much demand.
- Wheeling is more important to independent power producers as they do not own their own transmission lines.
- For generating least cost energy plans NUG (non-utility generation) & WHEELING contracts are most important supply options.

OPEN ACCESS CHARGES IN WHEELING:

1. Wheeling Charges or Distribution Charges

- charges which are paid to distribution licensee for the use of distribution system and associated facilities by another person for the conveyance of electricity.

2. Wheeling Loss or Distribution Loss

- Distribution losses are the technical losses for the distribution system. It is determined by the Commission for various voltage levels for the applicable year.

3. Transmission Charges

- Transmission charges are those charges which are paid to transmission licensee for the use of transmission system and associated facilities by another person for the conveyance of electricity.

4. Transmission Loss

- losses which are there in the transmission system. The buyers and sellers shall absorb apportioned energy losses in the transmission system in accordance with the provisions specified by the Central Commission.

5. PoC Charge & PoC Losses

- It is a transmission charge pricing introduced for sharing of Inter State Transmission Systems (ISTS) charges and Losses among the Designated ISTS Customers depending on their location and sensitive to their distances from load centers (generators) and generation (customers) .

NUG (Non utility generation)

- generation which is not owned by the utility in whose service area it is located.
- Includes private power generation companies (IPP) & Cogenerators.

disadvantages:

- Both wheeling & NUG options affect system security, voltage profile, losses & VAr reserves.
- There is a strain on the existing transmission system & will restrict economic utility dispatching.
- transmission access is another issue for NUG & Wheeling.
  - SEB is increasing pressure to open up their transmission system.
  - SEB have to evaluate each request for transmission access & assign a cost.
  - Cost figure includes marginal & embedded cost
    - Marginal cost is the change in total cost resulting from an extremely small change in output.
    - Embedded costs represent the total costs of all assets and ongoing charges incurred in providing and maintaining a supply of energy.
  - Var requirements & voltage profile should be also considered.

7ans:

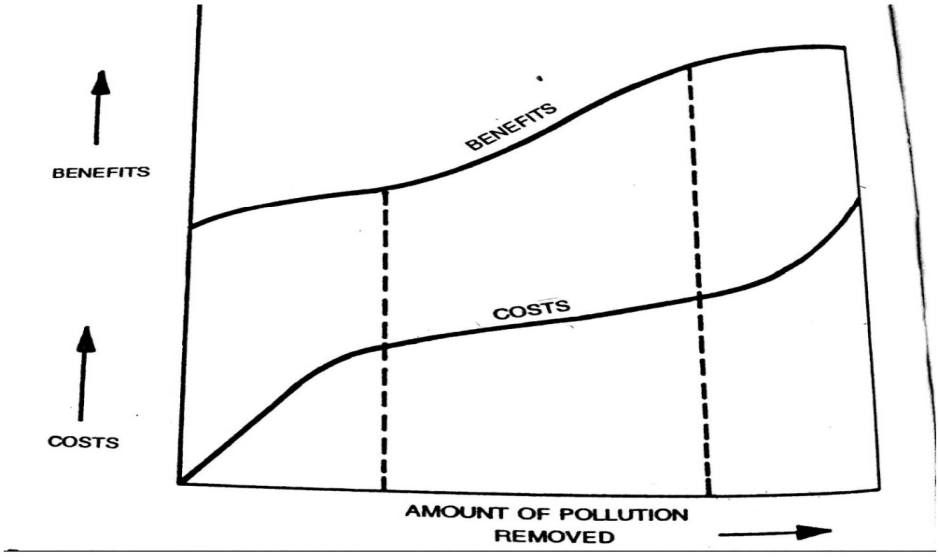
ENVIRONMENTAL EFFECTS (10.1)

- Generation of electricity is associated with **negative environmental effects**.
- **THERMAL POWER PLANTS:**
  - major contributors
  - Release **particulate matter** into atmosphere
  - **Coal combustion** results in **emission** of large amounts of CO_2
  - Significant quantities of **oxides of nitrogen & sulphur**.
  - They **react chemically with moisture** in upper atmosphere → **acid deposition on earth surface.**
  - **Technologies** are available **to control particulate emission.**
  - **Indian coal** has **low sulphur content** so **do not** contribute to **acid rain**.
  - But problem of **greenhouse gasses** is more.
  - Increase in concentration of CO_2 result **in global warming** → disruptive effects on temperature regimes , precipitation patterns & sea level.
- Impact is **not confined to local area**, it can be **regional or global.**
- So **problems** cannot be solved **unilaterally** by **any country.**
- So initiatives have been launched at **regional & global levels** for multi-country action.

SOME MEASURES TAKEN:

1. The standards of air & water pollution from power stations should be enforced vigorously.
2. Commercialization of clean coal technologies must be intensified.
3. Energy conservation must receive higher priority than before.
4. With growing technology & locations of new power stations , **environmental costs & benefits** should be taken into account as cost benefits curve.
5. Systematic **monitoring** of the quantity of **air & subsurface water** should be done.

FIG: COST BENEFIT APPROACH



NO_X REDUCTION MEASURES:

- No_x emissions can be reduced by 75% for natural gas operation
- 50% for oil operation by redesigning the burners & modifying fuel/air adjustment.

1. **REDUCTION OF EXCESS AIR:**

- Burner operation with reduction of excess air, it improves efficiency & reduces No_x emission.

2. **REDUCTION OF MIXING ENERGY:**

- **Lowering combustion air velocity & temperature & reducing the air whirl.**
- Velocity difference of fuel & air results in significant No_x reduction.

3. **REDUCTION OF AIR TEMPERATURE:**

- Sufficient amount of No_x can be decreased by lowering air temperature.
- This **results in a decrease in air velocity**.

4. **SEGREGATION OF FUEL & AIR:**

- When **asymmetric injection of fuel into the air**, fuel & **combustion air may segregate** & reduces No_x emission.

5. FUEL CONCENTRATION:

- Another way of lowering No_x emission is by **concentrating the fuel.**
- So air present reduces, thus combustion can be delayed.

6.BURNER RELATED FLUE GAS CIRCULATION:

- Flue gas is made to circulate in the burner.
- So temperature of circulating flue gas will be reduced.
- This also reduces No_x reduction.

7.STAGED COMBUSTION:

- We have to add several burner levels.
- At bottom furnace level 15% of Nox reduction can be attained.

TECHNOLOGICAL IMPACTS:

- **Choice of technology** to minimize emission has **5 routes:**

1. Higher efficiency in order to **burn less fuel** per unit of energy sent out.
2. **Cleaning of fuel** before combustion.
3. **Selection of a combustion process** that removes pollution at **source.**
4. Selection of **equipment** that removes pollution **after combustion**.
5. Selecting **end use energy efficient equipment**.

- So by one or a combination of these technologies , **emission from fossil fuel stations can be reduced.**

****