CMR
INSTITUTE OF
TECHNOLOGY

USN | | | | | | | | | |

Internal Assesment Test - I

Sub:	POWER SYSTEM PLANNING							Code:	10EE761
Date:	22/ 09/ 2017	Duration:	90 mins	Max Marks:	50	Sem:	7th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1	Explain least cost utility planning with the help of a flowchart.	[10]	CO2	L4
2	Explain structure of power system & types of power system network.	[10]	CO1	L4
3	Explain load forecasting techniques & load forecasting modeling.	[10]	CO2	L4
4 (a)	Explain Indian Electricity rule 1956.	[05]	CO1	L4
(b)	Explain different tools for power system planning.	[05]	CO1	L4
5	List out national action plans & goals associated with generation planning.	[10]	CO3	L1
6	What is co-generation? Describe two techniques of cogeneration with diagram.	[10]	CO3	L2
7	Explain i) Power pooling ii) Power Trading.	[10]	CO3	L4

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

CMR
INSTITUTE OF
TECHNOLOGY

USN | | | | | | | | | |

Internal Assesment Test - I

Sub:	POWER SYSTEM PLANNING							Code:	10EE761
Date:	22/ 09/ 2017	Duration:	90 mins	Max Marks:	50	Sem:	7th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1	Explain least cost utility planning with the help of a flowchart.	[10]	CO2	L4
2	Explain structure of power system & types of power system network.	[10]	CO1	L4
3	Explain load forecasting techniques & load forecasting modeling.	[10]	CO2	L4
4 (a)	Explain Indian Electricity rule 1956.	[05]	CO1	L4
(b)	Explain different tools for power system planning.	[05]	CO1	L4
5	List out national action plans & goals associated with generation planning.	[10]	CO3	L1
6	What is co-generation? Describe two techniques of cogeneration with diagram.	[10]	CO3	L2
7	Explain i) Power pooling ii) Power Trading.	[10]	CO3	L4

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

Answer key

1ans: 10 marks

NATIONAL & REGIONAL PLANNING:(1.6&1.7)

LEAST COST UTILITY PLANNING

- **Merits : Benefits consumers and suppliers**
  - Affordable **acquisition of resources**
  - Low in **cost**
  - **Environmentally** benign
  - **Acceptable to public**
  - **Reduced risk** faced by utilities.

- System expansion detailed project reports (DPRs) must be based on least cost planning and need to be made **mandatory** by **amending the Electricity (Supply) Act, 1948.**

NATIONAL & REGIONAL PLANNING:(1.6)

LEAST COST UTILITY PLANNING

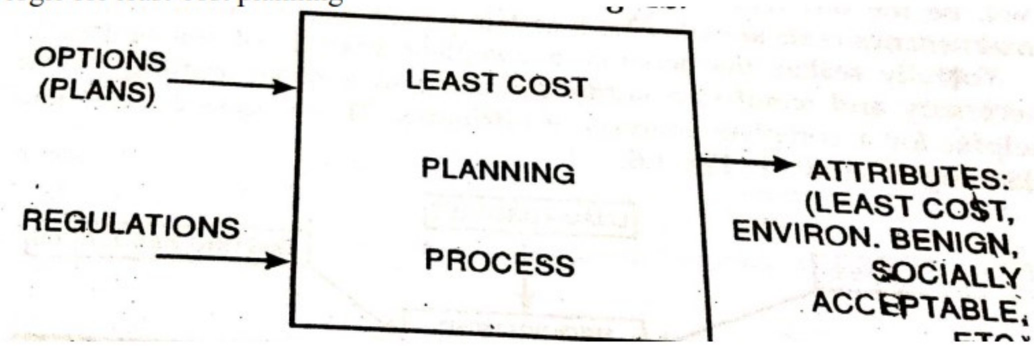
- **Short comings of traditional planning are:**
  - ✓ **Demand forecasting and investment planning** are considered sequential instead of interdependent
  - ✓ **Resource** planning is inefficient (shortage of resources)

- **Least cost utility planning :**
  - ✓ Is to **provide reliable electrical services** at the **lowest cost.**
  - ✓ Apply **supply and demand side resource** management
  - ✓ **End use efficiency**
  - ✓ **Load management**
  - ✓ **T & D options**
  - ✓ **Plant rehabilitation**
  - ✓ **Loss reduction** programmes
  - ✓ **conventional** centralized generation sources
  - ✓ **Decentralized** power generation-**non conventional sources**
  - ✓ Alternative tariff options

NATIONAL & REGIONAL PLANNING:(1.6&1.7)

LEAST COST UTILITY PLANNING

- The logic for least-cost planning



NATIONAL & REGIONAL PLANNING:(1.6&1.7)

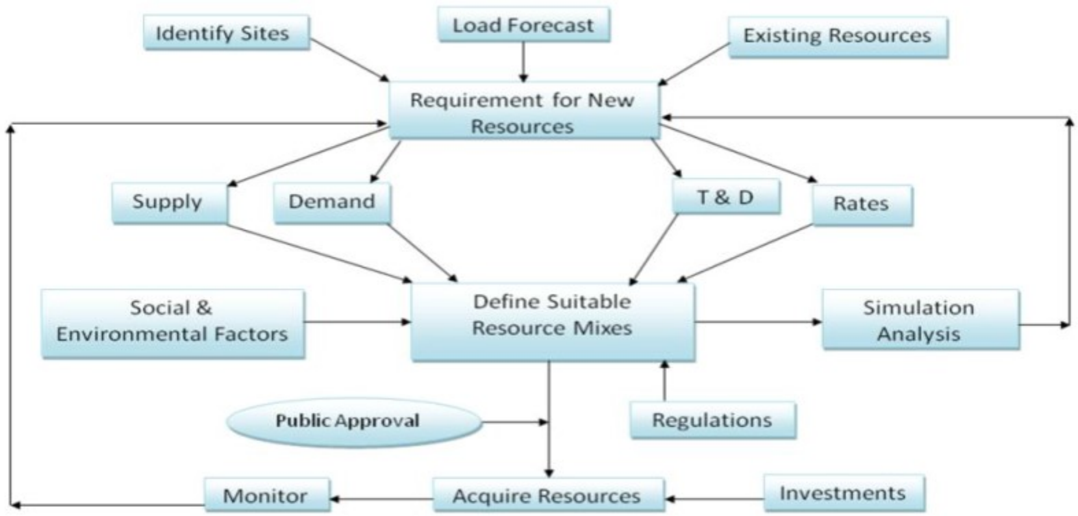
LEAST COST UTILITY PLANNING

- **Investments on power systems :**
  - **Capital cost**
  - **Interest** on **capital**
  - **Fuel cost**
  - **Operational and maintenance cost** – loss dependent

NATIONAL & REGIONAL PLANNING:(1.6&1.7)

LEAST COST UTILITY PLANNING

The process of least cost planning is shown:



NATIONAL & REGIONAL PLANNING:(1.6&1.7)

LEAST COST UTILITY PLANNING

- **Evaluation :**
  - **All options** should be **assessed in a consistent manner** for a full cycle
  - Once initial **evaluation is complete**, **environmental , economic factors** should be studied – avoids loosing out on options with high impact
  - Non cost factors should be evaluated – variability of factors, alternative solutions based on factor variation

2ans: **10 marks**

STRUCTURE OF POWER SYSTEM:(1.7)

Standard system KV Voltages (IS: 12360)		
Nominal Voltage in KV	**Maximum System Voltage**	**Remarks**
0.240	0.264	Distribution
0.415	0.457	
3.3	3.6	
6.6	7.2	
11.0	12.0	
22.0	24.0	
33.0	36.0	Distribution & Sub transmission
66.0	72.5	
132.0	145.0	Sub transmission & Transmission
220.0	245.0	
400.0	420.0	Transmission & Tie line
765.0	800.0	

STRUCTURE OF POWER SYSTEM:(1.7)

- The basic system consists of **energy resources** such as **hydro, coal, gas** etc.,
- a **prime mover, a generator and a load**.
- Some sort of **control system** is required for supervising it.

- The **prime mover may** be a **steam driven turbine, a hydraulic turbine or an internal combustion** engine.
- prime movers :**energy in the form of heat, falling water or fuel**

↓

into **rotation of the shaft**

↓

drives the **generator.**

STRUCTURE OF POWER SYSTEM:(1.7)

- **generator** may be **alternator or a d.c. machine**.
- Electrical **load** on the generator may be **lights, motors, heat or other devices**
- The **control system** functions: a) to keep the **speed of the machine constant**

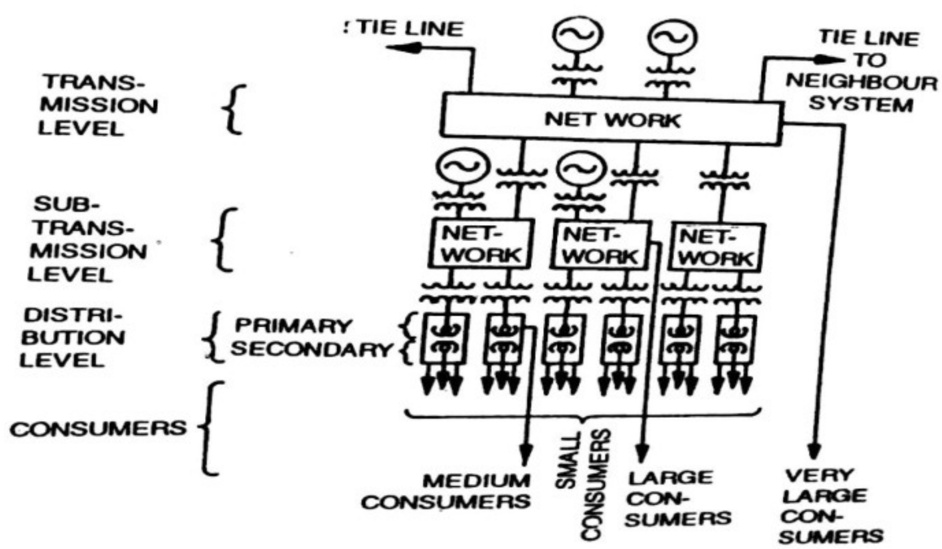
  b) the **voltage** within prescribed **limits**

  c)**excitation** within **the generator capability**.

- The **active power** (MW) is →(regulated by) frequency (speed) control
- The **reactive power** (MVAr) and voltage →(is regulated) by excitation control.
-

STRUCTURE OF POWER SYSTEM:(1.7)

Power system components

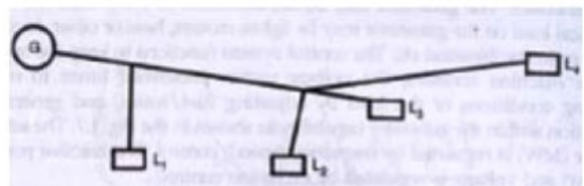


STRUCTURE OF POWER SYSTEM:(1.7)

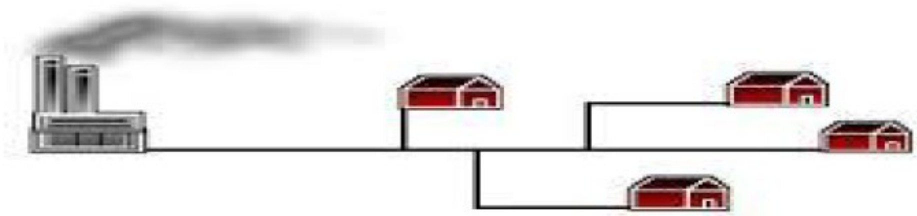
- The power **transmission and distribution network** may be of the following types

1. **radial system :**

- lines form a **'tree' spreading out** from the generator.
- **Opening any line** results in **interruption of power to one or more** of the loads.



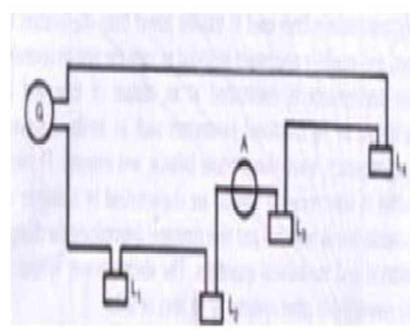
Radial System



STRUCTURE OF POWER SYSTEM:(1.7)

2. loop system :

- all loads will continue to be served even if one line section' is put out of service.
- In normal operation the loop may be open at some point at **A** as shown in the figure.
- In case a line section is to be taken out, the loop is first closed at **A**
- the line section is put on shut down.
- In this way **no service interruption occurs.**

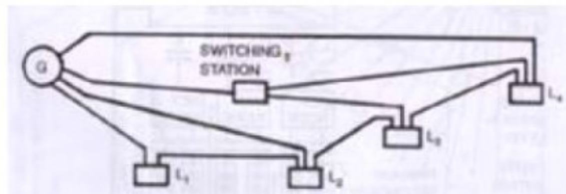


Loop System

STRUCTURE OF POWER SYSTEM:(1.7)

3. Network of line

- the **same loads being served by a network**.
- arrangement has a **higher reliability** as each load has **two or more circuits** of supply
- The **sub transmission and distribution circuits** are commonly designed as radial or loop circuits.
- The **high voltage transmission lines** are generally laid as interconnected or networks.
- Transmission and distribution are distinguished by their voltage levels.
- general, transmission systems have **bulk power handling capability,** and relatively **long lines** .
- connecting **generating stations** to **load centers** of the utilities.



Network of Lines

4ans: a) 5marks

THE ELECTRICITY REGULATIONS : (1.11)

- **Indian Electricity rules, 1956**

1. **Authorization of electric installations**
2. **Inspection of electric installations**
3. **Licensing**
4. **General safety precautions**
5. **General conditions relating to supply and use of energy**
6. **Electric supply lines, system and apparatus for low, medium, high and extra high voltages**
7. **Overhead lines**
8. **Electric traction**
9. **Additional precautions for mines and oil fields**
10. **Miscellaneous provisions**

b) 5 marks

PLANNING TOOLS : (1.9)

- **Aim :**
  - To supply power – **reliable**, **minimum cost**, **flexibility for expansion**

- **Criteria and constraints :**
  - **Reliability**
  - **Environment**
  - **Economics**
  - **Electricity pricing**
  - **Financial constraints**
  - **Society impacts**
  - **Value of electricity**

- **Criteria's conflict ✗ each other → making planning complex**

PLANNING TOOLS : (1.9)

- **Available tools : (3 basic techniques)**
  - **Simulation tools : Simulate the behavior of power system under certain conditions**
    - **Load flow**
    - **Short circuit studies**
    - **Fault studies**
    - **Transient studies**
    - **Harmonic studies**
    - **Production costing studies**
    - **Estimation of envr impact**

    generation reliability
    generation cost
    risk analysis
    optimum generation mix
    dynamic studies
    sub synchronous osc.
    system reliability eval.

  - **Optimization tools : Minimize / maximize an objective function**
    - **Optimum power**
    - **Least cost expansion**
    - **Generation expansion planning**

3ans: 10 marks

forecasting techniques (2.3) :

- Involves good judgment and sound knowledge of data manipulations as techniques are getting more complex
- time series analysis : yields trends in cyclic, seasonal, irregular variation
- Moving average :
  - arithmetic or weighted average of a no. of points of the series
  - A minimum of two years of past energy consumption is desirable, if seasonal effects are present.
  - more the history, the better
- Trend projections :
  - A trend line is fitted into the mathematical equation
  - it is projected into the future using the equation
  - study of the past behavior and mathematical modeling & extrapolation of the future behavior

forecasting techniques (2.3) :

- Trend projections : Two general approaches :

  1. Regression analysis :
     - Fitting of continuous math functions through actual data to achieve least overall error

  2. Fitting of a sequence on discontinuous lines / curves
     - Prevalent in short term forecasting

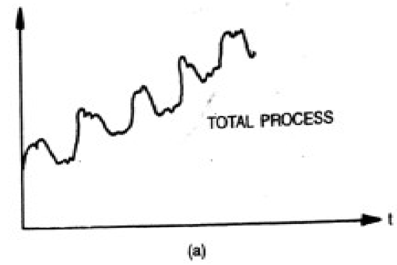
forecasting techniques (2.3) :

- **Power system load can be broken down :**

  (i) Basic trend
  (ii) Seasonal variation
  (iii) Cyclic variation :longer than the above causes the load pattern to be repeated (2/3 yrs)

  (iv) Random variations :day-to-day changes time of the week-(weekend, week day)

- The last three variations have a long-term mean of zero



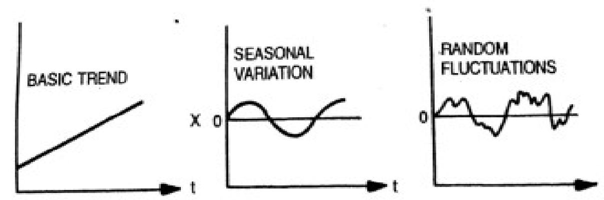


fig: Decomposition of typical load growth curve

Forecasting Modelling (2.4) :

2.Weather Dependent Factors :

- Weather is one of the **principal causes** of load variations
- as it affects domestic load, public lighting, commercial loads etc.
- essential to choose relevant weather variables
- **model their influence** on power consumption

Forecasting Modelling (2.4) :

Factors Affecting the Forecasting :

- many factors which influence the prediction of load
- vary from area to area and from country to country
- any factor ⇒ properly examined ⟶ forecasting model

1.Time dependent factors :

- Power systems exhibit **a time dependent pattern** of electric **load demand**.
- these factors **are regular, irregular or random** in nature.
- Regular pattern is exhibited during the **time of day, day of week and week of the year, and yearly growth**

Forecasting Modelling (2.4) :

3.Random Factors:

- **random phenomena** which affect **load consumption** and can cause **large errors** in load forecast.
- It is **difficult to accurately model their actual impact** on **load demand**.
- These include **school holidays, factory strikes**, and influence of popular **TV programmes**.
- Influence of these Phenomena can be studied if **past data** on these occurrences are available.

Forecasting Modelling (2.4) :

- In extrapolation, future load is treated as an extension of the past
- the load curve based on past data
- Technique ⟹ **detection of trends in the past** (various parameters) ⟹ **fitting a trend curve**-which could be a straight line, a parabola, exponential or a polynomial of other orders or a mix of the above ⟹ **finding coefficients of these curves** as given below

Forecasting Modelling (2.4) :

4.Other Factors:

- Other factors that influence the load demand include

(i) **Effects of DSEs (Distributed generating devices)**
(ii) Effects of rate tariff (time-of-day pricing, change in industrial tariffs)
(iii) Change over to winter time or summer time

- Impact of these factors in **past data** should be identified.
- **model should be selected** based on these factors
- Before use, the **model should be checked** to discover possible lack of fit
- necessary **correction** should be applied as required

Forecasting Modelling (2.4) :

Straight line $Y=a+bx$

Parabola $Y=a + bx+ cx^2$

S. curve $Y=a + bx +cx^2+dx^3$

Exponential $Y=be^{cx}$

Modified exponential $Y =a + be^{cx}$

Logistics $Y =1 / (a + be^{cx})$

Where Y is a variable to be fitted, x is time in assigned frame (in day, week, year etc.), and a, b ,c, d are coefficients be calculated.

Forecasting Modelling (2.4) :

- The mathematical models for domestic, commercial and other sectors have been determined by the CEA

Domestic sector:

- Energy in the domestic sector ➡ cooking, lighting, heating and other household appliances like TV, refrigerators etc.

- Increase in the family income ➡ **demand for electrical energy** in domestic sector.

.

- The following **model** has been adopted for **projecting the demand in the domestic sector**

$$\log Y = a + b \log X$$

Where Y = Energy consumption, **a and b =Constant** to be determined by Regression Analysis. **X=Private Final Consumption Expenditure**.

Forecasting Modelling (2.4) :

Commercial and Other sectors:

- The increased commercial activity has resulted in increasing use of energy.
- The use of electricity for illumination, weather comforts, refrigerators, air-conditioning and water heating is being increasingly resorted to.
- The other sectors, which mainly consist of public lighting, public water works.
- **energy consumption in the foreseeable future**
  - **industrial development**
  - **increasing urbanization**
  - **migration of population from rural to urban** areas
  - **electrification of villages**
  - **expansion of water facilities in the rural area**.

5ans: 10 marks

GOALS-NATIONAL ACTION PLAN

- CEA and World Bank the desirable options in India for the next 25 years are:

1. Accelerate hydro capacity development:
   - **Hydro** share **should be at least** around **40 per cent of the whole generation** for optimum operation of the system.
   - The site locations need to be identified on a long-term basis
   - Detailed Project Report should be prepared in advance.
   - Hydro power is urgent for developing peaking capability.
2. **Accelerated nuclear power development**:
   - India is the only developing country having a mature nuclear technology
   - Uses **natural uranium** in the **first phase** and **FBRs or LW thorium reactor** in the **second phase** .

GOALS-NATIONAL ACTION PLAN

3. **Reduction in T&D losses :**

- T&D losses ➡ 23 % to 15 % ➡ will save the generation capacity of about 6000MW.
- at rate of about 0.35 per cent reduction in T&D losses per year.
- About one-fourth of these losses are attributed to theft of energy.
- The other reasons are bad design of system: use of long LT lines, low voltage, low load density and long lines in rural areas.

GOALS-NATIONAL ACTION PLAN

4. The energy saving potential

industry →	25
agriculture →	30
Commercial / domestic sector →	10

- With overall 10 percent saving mission, about thousands MW installed capacity can be saved by **energy conservation** measures.

5. Studies show that demand management in regional systems

- installed capacity →(reduce) 10,000 to 20,000 MW
- shifting load from **peak hours to off peak** hours
- The country should switch to two time zones → one hour difference, i.e..One for the eastern states and one for the western state.

GOALS-NATIONAL ACTION PLAN

6. Renovation and modernization of existing thermal units and hydro units :

- will add capacity (**MW**)
- will improve the plant load factors
- will result in extended life of the plants

7. Formation and operation of the National Power Grid:

- according to Simulation studies → an overall saving 10,000 MW generation capacity ➡ reserve margin
- All the **five regions** at present are **deficit** in meeting peak load
- Installation of inter regional links (HVDC/HVAC) will improve hydro-thermal mix of combined regions and enable transmission of surplus energy.

GOALS-NATIONAL ACTION PLAN

8. scope for co-generation :

- in large industries such as **sugar, textile, alcohol, paper, petro-chemical and metallurgical works.**
- Cogeneration potential in the country is to the order of 10,000 MW in the **sugar** industry.
- It should be mandatory for **cement**, steel, fertilizer and chemical plants having load above 15MW to install captive power.
- **The Indian Electricity (Supply) Act 1948** must be amended to make the installation of captive power by such plants mandatory.
- There is **need for** comprehensive legislation towards compulsory co-generation and feeding into the grid for the sake of conserving natural energy resources

GOALS-NATIONAL ACTION PLAN

9. In the rural areas only, there is scope for wind farm generation of up to 20,000MW.

- Solar photovoltaic has great potential for **rural street lighting, home lighting, operating pumps** etc.
- The Ministry of Non-conventional Energy Sources has drawn an ambitious programme touching at least 1,00,000 villages through photovoltaic's.
- At 1996 about 0.25 million modules are installed in the country and this number is likely to exceed 50 millions by the year 2020.

6ans:10 marks

COGENERATION / CAPTIVE POWER (3.5):

- There is large scope for cogeneration ➡ 50000MW in India
- in industries such as sugar, textile, alcohol, paper, petro-chemicals and metallurgical.
- It should be made mandatory for **cement, steel, aluminium, fertilizers, chemical plants** and other heavy industry to install captive power.
- Consumers could **utilize the waste heat** produced in heavy power-intensive industries having load more than 5 MW, such as steel, aluminium plants.

COGENERATION / CAPTIVE POWER (3.5):

Potential industries	Mandatory industries
Sugar	Cement
Textile	Aluminum
Alcohol	Fertilizers
Paper	Chemical plants
Petrochemicals	Heavy industries
Metallurgical	Induction / arc furnace

COGENERATION / CAPTIVE POWER (3.5):

- They must **install cogeneration plants/captive power generation** plants for the sake of economical power generation.

- A **cogeneration facility** produces **electrical energy** and **other forms** of useful **thermal energy** (such as heat and steam) used for industrial, commercial, heating or cooling purposes.

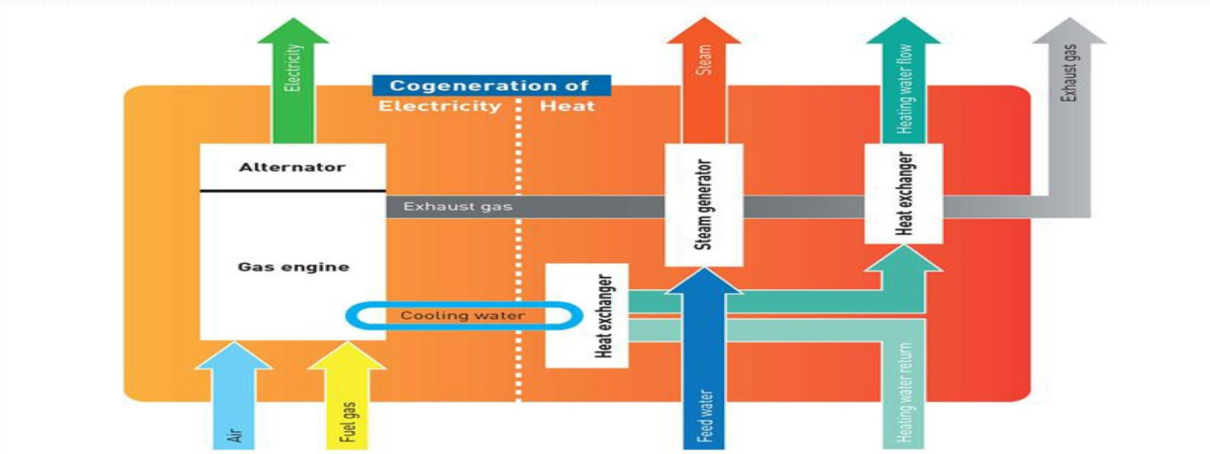
- In the **combustion of fuel**, **energy is released** which is used for **heating** or to perform some useful form of work.

- Not **all of the energy** that is produced can be used; some of it is **wasted.**

- A **cogeneration facility recaptures** some of the waste energy that otherwise would escape and puts it to **useful purpose**.

COGENERATION / CAPTIVE POWER (3.5):

- **Cogeneration** can be used in almost **any industry** with some type of thermal need.
- **small packaged cogeneration units** → for **hospitals, shopping complexes and small manufacturing** firms



COGENERATION / CAPTIVE POWER (3.5):

- **Cogeneration systems** are **more expensive .**
- Cost more to operate and maintain than systems that produce only **thermal energy**.

- factors to consider in deciding on cogeneration:

1. Degree of waste recovery
2. duty cycle
3. capital cost
4. fuel and electricity prices
5. Taxes
6. reliability
7. size

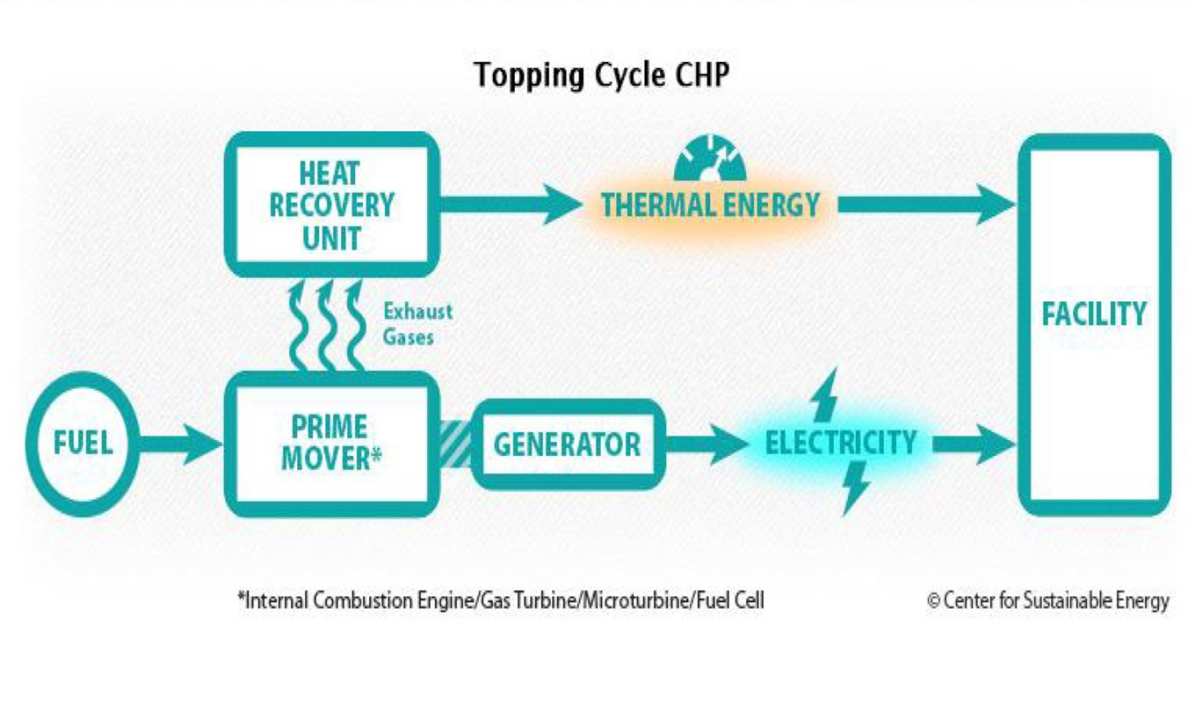
COGENERATION / CAPTIVE POWER (3.5):

- **Two basic processes** a cogeneration facility may utilize.
  1. topping cycle process - most common
  2. **bottoming cycle process**

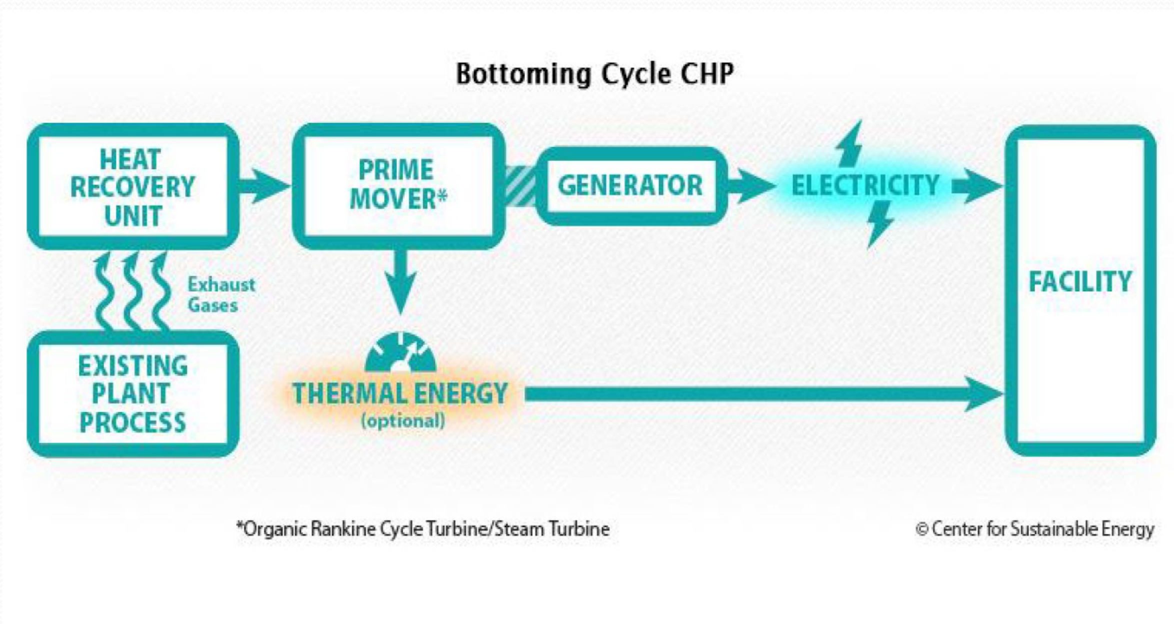
- In the topping cycle process, electricity is produced first and the **waste energy being recovered** is in the form of thermal energy.

- In the **bottoming cycle**, the thermal energy is first used in a process and the waste energy recovered from that process is used to produce electricity.

COGENERATION / CAPTIVE POWER (3.5):



COGENERATION / CAPTIVE POWER (3.5):



7ans: 10 marks

POWER POOLING AND TRADING

- A power pool is a situation where output from different power plants are "pooled" together.
- dispatched according to this "merit order" to meet demand.
- Power pooling is used to balance electrical load over a larger network (electrical grid) than a single utility.
- With respect to pool terminology,
- tight and loose power pools (as termed in the US)
- relate to the centralization and mandatory nature of power pooling arrangements.
- power pools in the US → New York Power Pool (NYPP)
- New England Power Pool (NEPOOL)
- The pool serves two main functions: price determination and physical trading.
- Price determination is like → stock exchange or an antique auction
- the prices are determined by the bids followed by the actual exchange of stock .

POWER POOLING AND TRADING

- Power cannot be stored, hence generation = demand
- **Sample system of UK :**
  - Regional and national grid companies form a **pool**
  - The companies compete for wholesale generation
  - Energy is sold in bulk in wholesale market
  - **Spot price** is determined for **half-hour basis** in national power load curve period through competitive bidding by individual generators
  - Pool is a mechanism to allow trading or sharing between power utilities and generators
  - Long term contracts in sales and purchase are made between utilities and generating companies based on **set of rules evolved.**
  - Spot trading in **short term market** reflect supply and demand on short term basis

POWER POOLING AND TRADING

Settlement system in UK :

- Price and payments are calculated under **pool wheeling** arrangements
- **Grid operator** seeks to **schedule & dispatch** generating units subject to constraints , to meet demand and maintain reserve.
- Before 10am on the day ahead of actual operation, each utility submits to the grid operator an offer for generating sets :
  - Generators' price
  - Availability
  - Operating characteristics of the set

POWER POOLING AND TRADING

- All offers of the period + demand forecast + planned reserve are fed to the computer to match the demand and supply at least cost.
- The **schedule is generated** – pool purchase price (PPP) is decided for **half hour**
- PPP consists of :
  - system marginal price :
    - **price derived from offer prices** of the marginal generating sets scheduled in the unconstrained schedule for the relevant period.
  - Capacity element :
    - calculated according to **Loss of Load Probability (LOLP)**

POWER POOLING AND TRADING

- Pool input price – national grid company pays to generators
- Pool output price – price charged from public electricity suppliers

- Pool is a spot market which operates in real time.

- **Tariff** for retail market is decided observing the **pool output system**
- The consumers are made aware of efficiency and load management through **tariffs.**

- Consumers to purchase power from renewable energy sources- Non fossil fuel obligations
- The public electricity suppliers purchase electricity from the RES generators

POWER POOLING AND TRADING

- On any day , payments must be balanced in the pool

- Pool selling price (PSP)– to be recovered from the suppliers

- PPP-PSP = uplift

- Uplift is to pay for :
  - Cost of ancillary services
  - Payments for reserve
  - Difference between unconstrained scheduling and actual operation

POWER POOLING AND TRADING

- USA:
  - Vertically integrated **utilities in each state** with **independent power generators**
  - Sell bulk power to utilities
  - Competition to construct and operate new power stations
  - Limited spot market and wholesale generation
  - Utilities have monopoly in retail supplies

- India :
  - Yet to formulate commercial guidelines for wheeling of power
  - A **rational tariff** structure to encourage **selling and buying** of power
  - Measures are devised to discourage high frequency operation of grid

****