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Internal Assessment Test 1 – SEPTEMBER 2016

Sub:	Power system planning					Code:	10EE761
Date:	08-09-2016	Duration:	90 mins	Max Marks:	50	Sem: 7	Branch: EEE

Note: **Answer any five full questions. Sketch figures wherever necessary.**

1. Explain the concept of least- cost utility planning with the aid of flowchart. [10]
2. Explain the different tools for power system planning. List out the constraints in planning an energy system. [10]
3. Illustrate the different factors affecting forecasting and hence explain mathematical modeling simulation considering domestic, commercial & other sectors. [10]
4. List out national action plans & goals associated with generation planning. [10]
5. Explain private participation with respect to ownership options and modes of participation.[10]

P.T.O

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Internal Assessment Test 2 –SEPTEMBER 2016

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Date:	08-09-2016	Duration:	90 mins	Max Marks:	50	Sem: 7	Branch: EEE

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7. Discuss the objectives of sound pricing structure. Also explain the main objectives and types of rational tariffs. [10]

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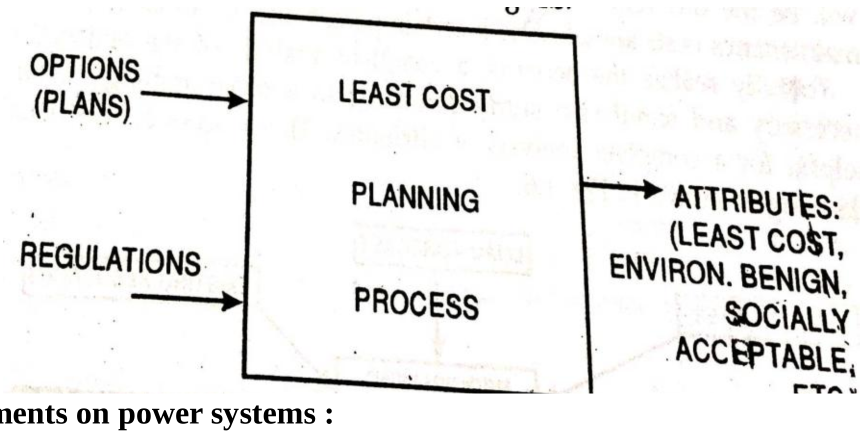
Answer key

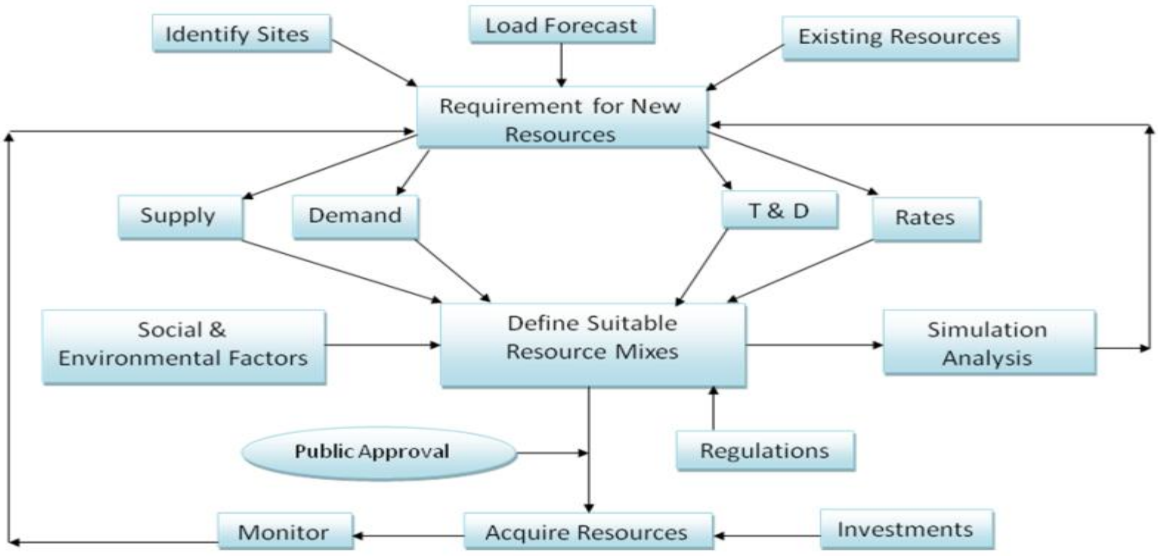
1. **LEAST COST UTILITY PLANNING**

- **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

- **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.**
    - The logic for least-cost planning



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



- **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

2. **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**
- Available tools : (3 basic techniques)
  - Simulation tools : Simulate the behavior of power system under certain conditions
    - Load flow — generation reliability
    - Short circuit studies — generation cost
    - Fault studies — risk analysis
    - Transient studies — optimum generation mix
    - Harmonic studies — dynamic studies
    - Production costing studies — sub synchronous osc.
    - Estimation of envr impact — system reliability eval.
  - Optimization tools : Minimize / maximize an objective function

- Optimum power
- Least cost expansion

Generation expansion planning

- Scenario techniques :
  - A description of probable or possible sequence of events is developed.
  - The events are recorded into a case history & a database is build.
  - All possible outcomes are investigated
  - Done by state electricity boards, research organizations
  - Utilities should prepare integrated resource plans
- The long term plans seek to develop the best mix of demand and supply option to meet consumer needs for energy.

3.

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**
- **Irregular pattern** **holidays, weekends, special days** etc
- **load requirements** tend to **differ on these days** than on other days.
- load patterns are different **on weekdays and weekends**
- **holidays and special days** on **load demand**

  extent of public participation

  impact on **industrial activity**

  state-level celebrations requiring excessive **lighting load**

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
- Principal weather variables **temperature, cloud cover, visibility & precipitation.**
- The first two factors affect the domestic/office (e.g., heating, cooling) loads
- others affect lighting loads as they affect daylight illumination.

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.

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

Mathematical Modelling-Simulation:

- ✓ In modelling, **the total load** is considered to be **the sum total of various components due to various factors**.
- ✓ These **factors** need to be measured and interrelated with load requirements.
- ✓ **individual modelling** of each **load type**
- ✓ identifying their interrelationship **to arrive at future load requirements**
- ✓ This is **mathematical modelling**
- ✓ **physical problems** **a computer can understand**
- ✓ The strength of a method lies in the **accuracy of the results** it gives.
- ✓ **Errors in predicted loads** are found **mainly in peak periods**, **transitional phase** (from peak to off peak and vice-versa), and on **weekends and special days**.

- 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

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

- 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**.

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.

- The public lighting system in the urban areas is also likely to develop further due to increased demand for energy.
- The increase in the number of urban households has, therefore, a close relationship with the increase in energy demand relating to other sectors.
- As such, a. similar model has been adopted for projecting the energy demand is these sectors separately.

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

  Y =Energy consumption

  a and b=Constants to be determined by **Regression Analysis**

  X=Number of urban households

Requirements of a good load forecast programme :

(i) Accuracy of results (in real-time operation for a long period of time)

(ii) Its adaptive nature (e.g., model parameters can be changed on-line to track seasonal load variations or variation of impact of different components of load etc.)

(iii) Being computationally efficient (in terms of data requirements, processing time and memory requirements)

(iv) Its being easy to implement and use.

4. **GOALS-NATIONAL ACTION PLAN**

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

1. <u>Accelerate hydro capacity development</u>:
   - **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. **<u>Accelerated nuclear power development</u>:**
   - 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** .
3. **<u>Reduction in T&D losses :</u>**

- 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.

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.

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.

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

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

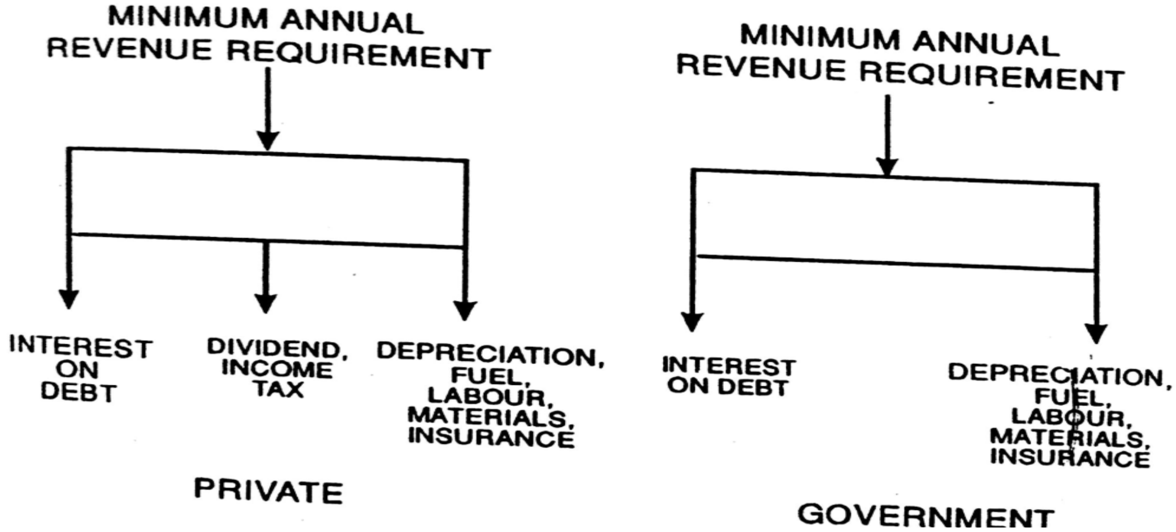
- Solar photovoltaic has great potential for **rural street lighting, home lighting, operating pumps** etc.

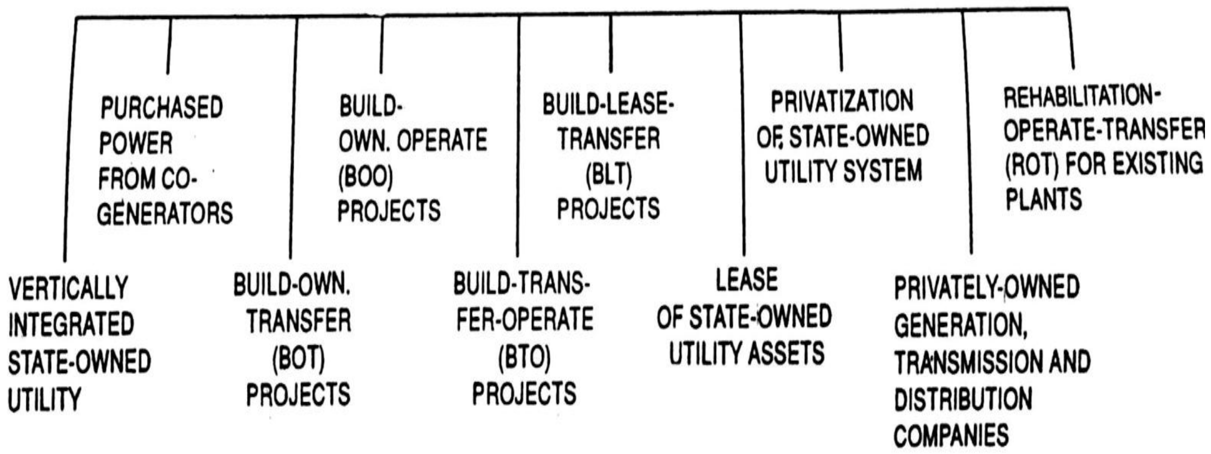
- The Ministry of Non-conventional Energy Sources has drawn an ambitious programme touching at least 1,00,000 villages through photovoltaic's.
- At 1996 about 0.25 million modules are installed in the country and this number is likely to exceed 50 millions by the year 2020.

5ans: **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.**

- 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**.





- **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**.

. **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.
Return for **producers**.

6ans: **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**.
- The concerns are **Rural electrification** concerns the **supply of electricity to low density areas of villages**.
- 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**.

<u>COMPONENTS OF RURAL ELECTRIFICATION PLANNING :</u>

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.**

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.

7ans: **3 main objectives of sound pricing structure/consumer tariff**

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.

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)**

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

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