← Calculate Transverse Load on PCC/RCC/Tublar/RSJ Pole.
Guideline to Design Electrical Network for Building / Small Area. →

Demand Factor-Diversity Factor-Utilization Factor-Load Factor

October 31, 2011 108 Comments

(1) Demand factor (in IEC, Max.Utilization factor (Ku)):

- The word "demand" itself says the meaning of Demand Factor. The ratio of the maximum coincident demand of a system, or part of a system, to the total connected load of the system.

- ### Demand Factor = Maximum demand / Total connected load

- For example, an over sized motor 20 Kw drives a constant 15 Kw load whenever it is ON. The motor demand factor is then 15/20 =0.75= 75 %.
- Demand Factor is express as a percentage (%) or in a ratio (less than 1).

- ### *Demand factor is always < =1.*

- Demand Factor is always change with the time to time or hours to hours of use and it will not constant.
- The connected load is always known so it will be easy to calculate the maximum demand if the demand factor for a certain supply is known at different time intervals and seasons.
- ***The lower the demand factor, the less system capacity required to serve the connected load.***

- ### Calculation:

- (1) A Residence Consumer has 10 No's Lamp of 400 W but at the same time It is possible that only 9 No's of Bulbs are used at the same time. Here Total Connected load is 10×40=400 W. Consumer maximum demand is 9×40=360 W. Demand Facto of this Load = 360/400 =0.9 or 90%.
- (2) One Consumer have 10 lights at 60 Kw each in Kitchen, the load is 60 Kw x 10 = 600 KW. This will be true only if All lights are Turns ON the same time (Demand factor=100% or 1)
- For this Consumer it is observed that only half of the lights being turned ON at a time so we can say that the demand factor is 0.5 (50%). The estimated load = 600 Kw X 0.5 = 300 Kw.

- ### Use of demand factors:

- Feeder conductors should have sufficient Ampere Capacity to carry the load. The Ampere Capacity does not always be equal to the total of all loads on connected branch-circuits.
- This factor must be applied to each individual load, with particular attention to electric motors, which are very rarely operated at full load.
- As per National Electrical Code (NEC) demand factor may be applied to the total load. The demand factor permits a feeder ampearcity to be less than 100 percent of all the branch-circuit loads connected to it.
- Demand factor can be applied to calculate the size of the sub-main which is feeding a Sub panel or a fixed load like a motor etc. If the panel have total load of 250 kVA , considering a Demand factor of 0.8, we can size the feeder cable for 250 x 0.8= 200 kVA.
- Demand factors for buildings typically range between 50 and 80 % of the connected load.
- In an industrial installation this factor may be estimated on an average at 0.75 for motors.

- For incandescent-lighting loads, the factor always equals 1.

Demand Factor For Industrial Load	
Text Book of Design of Elect. Installation- Jain	
Electrical Load	**Demand Factor**
1 No of Motor	1
Up to 10 No's of Motor	0.75
Up to 20 No's of Motor	0.65
Up to 30 No's of Motor	0.6
Up to 40 No's of Motor	0.5
Up to 50 No's of Motor	0.4

Demand Factor	
Text Book of Design of Elect. Installation- Jain	
Utility	**Demand Factor**
Office ,School	0.4
Hospital	0.5
Air Port, Bank, Shops,	0.6
Restaurant, Factory,	0.7
Work Shop, Factory (24Hr Shift)	0.8
Arc Furnace	0.9
Compressor	0.5
Hand tools	0.4
Inductance Furnace	0.8

Demand Factor	
Saudi Electricity Company Distribution Standard	
Utility	**Demand Factor**
Residential	0.6
Commercial	0.7
Flats	0.7
Hotel	0.75
Mall	0.7
Restaurant	0.7
Office	0.7
School	0.8
Common Area in building	0.8
Public Facility	0.75
Street Light	0.9
Indoor Parking	0.8

Outdoor Parking	0.9
Park / Garden	0.8
Hospital	0.8
Workshops	0.6
Ware House	0.7
Farms	0.9
Fuel Station	0.7
Factories	0.9

Demand Factor	
Text Book of Principal of Power System-V.K.Mehta	
Utility	**Demand Factor**
Residence Load (<0.25 KW)	1
Residence Load (<0.5 KW)	0.6
Residence Load (>0.1 KW)	0.5
Restaurant	0.7
Theatre	0.6
Hotel	0.5
School	0.55
Small Industry	0.6
Store	0.7
Motor Load (up to 10HP)	0.75
Motor Load (10HP to 20HP)	0.65
Motor Load (20HP to 100HP)	0.55
Motor Load (Above 100HP)	0.50

(2) Diversity factor:

- Diversity Factor is ratio of the sum of the individual maximum demands of the various sub circuit of a system to the maximum demand of the whole system.
- **Diversity Factor = Sum of Individual Maximum Demands / Maximum Demand of the System.**
- Diversity Factor = Installed load / Running load.
- ***The diversity factor is always >= 1.***
- Diversity Factor is always >1 because sum of individual max. Demands >Max. Demand.
- In other terms, Diversity Factor (0 to 100%) is a fraction of Total Load that is particular item contributed to peak demand. 70% diversity means that the device operates at its nominal or maximum load level 70% of the time that it is connected and turned ON.
- It is expressed as a percentage (%) or a ratio more than 1.
- **If we use diversity value in % than it should be multiply with Load and if we use in numerical value (>1) than it should be divided with Load.**

- Diversity occurs in an operating system because all loads connected to the System are not operating simultaneously or are not simultaneously operating at their maximum rating. The diversity factor shows that the whole electrical load does not equal the sum of its parts due to this time Interdependence (i.e. diverseness).
- In general terms we can say that diversity factor refers to the percent of time available that a machine. 70% diversity means that the device operates at its nominal or maximum load level 70% of the time that it is connected and turned ON.
- Consider two Feeders with the same maximum demand but that occur at different intervals of time. When supplied by the same feeder, the demand on such is less the sum of the two demands. In electrical design, this condition is known as diversity.
- Diversity factor is an extended version of demand factor. It deals with maximum demand of different units at a time/Maximum demand of the entire system.
- **Greater the diversity factor, lesser is the cost of generation of power.**
- Many designers prefer to use unity as the diversity factor in calculations for planning conservatism because of plant load growth uncertainties. Local experience can justify using a diversity factor larger than unity, and smaller service entrance conductors and transformer requirements chosen accordingly.
- The diversity factor for all other installations will be different, and would be based upon a local evaluation of the loads to be applied at different moments in time. Assuming it to be 1.0 may, on some occasions, result in a supply feeder and equipment rating that is rather larger than the local installation warrants, and an over-investment in cable and equipment to handle the rated load current. It is better to evaluate the pattern of usage of the loads and calculate an acceptable diversity factor for each particular case.

- ## Calculation:

- One Main Feeder have two Sub feeder (Sub Feeder A and Sub Feeder B), Sub Feeder-A have demand at a time is 35 KW and Sub Feeder-B have demands at a time is 42 KW, but the maximum demand of Main Feeder is 70 KW.
- Total individual Maximum Demand =35+42=77 KW.
- Maximum Demand of whole System=70 KW
- So Diversity factor of The System= 77/70 =1.1
- Diversity factor can shoot up above 1.

- ## Use of diversity factor:

- The Diversity Factor is applied to each group of loads (e.g. being supplied from a distribution or sub-distribution board).
- Diversity factor is commonly used for a complete a coordination study for a system. This diversity factor is used to estimate the load of a particular node in the system.
- Diversity factor can be used to estimate the total load required for a facility or to size the Transformer
- Diversity factors have been developed for main feeders supplying a number of feeders, and typically 1.2 to 1.3 for Residence Consumer and 1.1 to 1.2 for Commercial Load. 1.50 to 2.00 for power and lighting loads.
- Note: Reciprocal of the above ratio (will be more than 1) also is used in some other countries.
- Diversity factor is mostly used for distribution feeder size and transformer as well as to determine the maximum peak load and diversity factor is always based on knowing the process. You have to understand what will be on or off at a given time for different buildings and this will size the feeder. Note for typical buildings diversity factor is always one. You have to estimate or have a data records to create 24 hours load graph and you can determine the maximum demand load for node then you can easily determine the feeder and transformer size.
- The diversity factor of a feeder would be the sum of the maximum demands of the individual consumers divided by the maximum demand of the feeder. In the same manner, it is possible to compute the diversity factor on a substation, a transmission line or a whole utility system.

- The residential load has the highest diversity factor. Industrial loads have low diversity factors usually of 1.4, street light practically unity and other loads vary between these limits.

Diversity Factor in distribution Network				
(Standard Handbook for Electrical Engineers" by Fink and Beaty)				
Elements of System	**Residential**	**Commercial**	**General Power**	**Large Industrial**
Between individual users	2.00	1.46	1.45	
Between transformers	1.30	1.30	1.35	1.05
Between feeders	1.15	1.15	1.15	1.05
Between substations	1.10	1.10	1.10	1.10
From users to transformers	2.00	1.46	1.44	
From users to feeder	2.60	1.90	1.95	1.15
From users to substation	3.00	2.18	2.24	1.32
From users to generating station	3.29	2.40	2.46	1.45

Diversity Factor for Distribution Switchboards	
Number of circuits	Diversity Factor in % (ks)
Assemblies entirely tested 2 and 3	90%
4 and 5	80%
6 to 9	70%
10 and more	60%
Assemblies partially tested in every case choose	100%

Diversity Factor as per IEC 60439	
Circuits Function	**Diversity Factor in % (ks)**
Lighting	90%
Heating and air conditioning	80%
Socket-outlets	70%
Lifts and catering hoist	
For the most powerful motor	100%
For the second most powerful motor	75%
For all motors	80%

Diversity Factor for Apartment block

Apartment	Diversity Factor in % (ks)
2 To 4	1
5To 19	0.78
10To 14	0.63
15To 19	0.53
20To 24	0.49
25To 29	0.46
30 To 34	0.44
35 To 39	0.42
40To 40	0.41
50 To Above	0.40

Diversity Factor			
Text Book of Principal of Power System-V.K.Mehta			
Area	**Residence Ltg**	**Commercial Ltg**	**Ind. Ltg**
Between Consumer	3	1.5	1.5
Between Transformer	1.3	1.3	1.3
Between Feeder	1.2	1.2	1.2
Between S.S	1.1	1.1	1.1

(3) Load factor:

- The ratio of the Actual Load of equipment to Full load of equipment.
- **Load Factor=Actual Load / Full Load**
- It is the ratio of actual kilowatt-Hours used in a given period, divided by the total possible kilowatt -hours that could have been used in the same period at the peak KW level.
- **Load Factor = (energy (kWh per month)) / (peak demand (kW) x hours/month)**
- In other terms Load factor is defined as the ratio of Average load to maximum demand during a given period.
- **Load Factor= Average Load / Maximum Demand during given Time Period**
- ***The Load factor is always <=1.***
- Load Factor is always less than 1 because maximum demand is always more than average demand.
- Load Factor can be calculated for a single day, for a month or for a year.
- Load factor in other terms of efficiency.
- It is used for determining the overall cost per unit generated.
- Higher the load factor is GOOD and it will more Output of Plan, lesser the cost per unit which means an electricity generator can sell more electricity at a higher spark spread, Fixed costs are spread over more kWh of output. A power plant may be highly efficient at High load factors.
- Low load factor is a BED. A low load factor will use electricity inefficiently relative to what we could be if we were controlling our peak demand. A power plant may be less efficient at low load factors.
- For almost constant loads, the load factor is close to unity.
- For Varying Load Factor is closed Zero.

- Load Factor is a measure of the effective utilization of the load and distribution equipment, i.e. higher load factor means better utilization of the transformer, line or cable.
- A high load factor means power usage is relatively constant. Low load factor shows that occasionally a high demand is set. To service that peak, capacity is sitting idle for long periods, thereby imposing higher costs on the system. Electrical rates are designed so that customers with high load factor are charged less overall per kWh.
- Sometimes utility companies will encourage industrial customers to improve their load factors.
- ***Load factor is term that does not appear on your utility bill, but does affect electricity costs. Load factor indicates how efficiently the customer is using peak demand.***
- **Calculation:**

- Motor of 20 hp drives a constant 15 hp load whenever it is on.
- The motor load factor is then 15/20 = 75%.

Demand Factor & Load Factor

Introduction to Power Requirement for Building – J. Paul Guyer,		
Utility	**Demand Factor (%)**	**Load Factor (%)**
Communications – buildings	60-65	70-75
Telephone exchange building	55-70	20-25
Air passenger terminal building	65-80	28-32
Aircraft fire and rescue station	25-35	13-17
Aircraft line operations building	65-80	24-28
Academic instruction building	40-60	22-26
Applied instruction building	35-65	24-28
Chemistry and Toxicology Laboratory	70-80	22-28
Materials Laboratory	30-35	27-32
Physics Laboratory	70-80	22-28
Electrical and electronics laboratory	20-30	3-7
Cold storage warehouse	70-75	20-25
General warehouse	75-80	23-28
Controlled humidity warehouse	60-65	33-38
Hazardous/flammable storehouse	75-80	20-25
Disposal, salvage, scrap building	35-40	25-20
Hospital	38-42	45-50
Laboratory	32-37	20-25
K-6 schools	75-80	10-15
7-12 schools	65-70	12-17
Churches	65-70	5-25
Post Office	75-80	20-25
Retail store	65-70	25-32
Bank	75-80	20-25
Supermarket	55-60	25-30
Restaurant	45-75	15-25
Auto repair shop	40-60	15-20
Hobby shop, art/crafts	30-40	25-30
Bowling alley	70-75	10-15
Gymnasium	70-75	20-45

Skating rink	70-75	10-15
Indoor swimming pool	55-60	25-50
Theatres	45-55	8-13
Library	75-80	30-35
Golf clubhouse	75-80	15-20
Museum	75-80	30-35

(4) Coincidence factor (in IEC, Factor of simultaneity (ks)):

- The reciprocal of diversity factor is coincidence factor
- The coincidence factor is the ratio of the maximum demand of a system, or part under consideration, to the sum of the individual maximum demands of the subdivisions

- **Coincidence factor = Maximum demand / Sum of individual maximum demands**

- Expressed as a percentage (%) or a ratio less than 1.

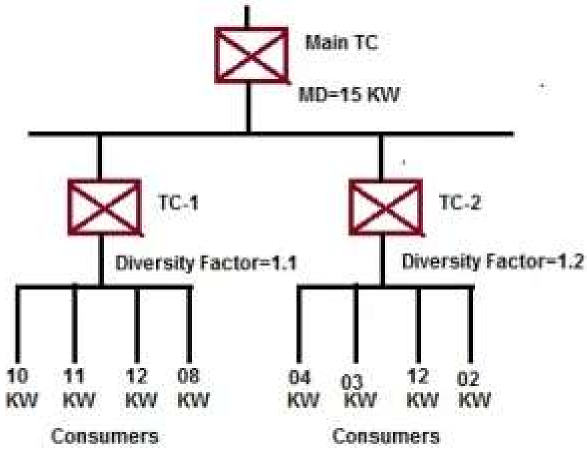
- ***The Confidence Factor is always <=1.***

- Usually Confidence Factor will decrease as the number of connected customer's increases.
- The factor ks is applied to each group of loads (e.g. distribution or sub-distribution board).
- The determination of these factors is the responsibility of the designer, since it requires a detailed knowledge of the installation and the conditions in which the individual circuits are to be exploited. For this reason, it is not possible to give precise values for general application.

(5) Maximum demand:

- The maximum demand of an installation is the maximum rate of consumption expressed in amperes, kW or kVA. It is generally taken as the average rate of consumption over a period of time. Example the 15-minute maximum kW demand for the week was 150 kW. Maximum demand does not include motor starting currents or other transient effects. Fault currents and overload currents are also excluded. Maximum demand in KW is relevant only for metering/tariff purposes.
- Maximum demand (often referred to as MD) is the largest current normally carried by circuits, switches and protective devices. It does not include the levels of current flowing under overload or short circuit conditions.
- Maximum Demand is a greatest of all demands that occur during a specific time
- The major disadvantage of allocating load using the diversity factors is that most utilities will not have a table of diversity factors and sometime it is not viable to determine accurate Diversity Factor. In this situation Maximum Demand is very helpful to calculate size of Feeder or TC.
- The kVA rating of all distribution transformers is always known for a feeder. The metered readings can be taken to each transformer based upon the transformer rating. An "allocation factor" (AF) can be calculate.
- Allocation Factor= Metered Demand (KVA) / Total KVA.
- **Equipment Demand= AF x Total KVA of Equipments**

- **Calculation:**
- Actual Loading or Size of TC-1 and TC-2.



- Total Load on TC-1 =10+11+12+08= 41 KW.
- Maximum Diversity Demand of TC-1= 41 / 1.1 = 37.3 KW.
- Total Load on TC-2 =4+3+12+02= 21 KW.
- Maximum Diversity Demand of TC-2= 21 / 1.2 = 17.5 KW.
- Total Load= 37.3 + 17.5 =54.8 KW.
- Allocating Factor (AF)= M.D / Total Load
- Allocating Factor (AF)= 0.27.
- **Actual Load on TC-1=0.27×37.3 = 1.20 KW.**
- **Actual Load on TC-2=0.27×17.5 = 4.8 KW.**
- Assessment of maximum demand is very easy for Resistive Load , For example, the maximum demand of a 240 V single-phase 8 kW shower heater can be calculated by dividing the power (8 kW) by the voltage (240 V) to give a current of 33.3 A. This calculation assumes a power factor of unity, which is a reasonable assumption for such a purely resistive load.
- Lighting circuits pose a special problem when determining MD. Discharge lamps are particularly difficult to assess, and current cannot be calculated simply by dividing lamp power by supply voltage. The reasons for this are Control gear losses result in additional current, the power factor is usually less than unity so current is greater, and Chokes and other control gear usually distort the waveform of the current so that it contains harmonics which are additional to the fundamental supply current.
- So long as the power factor of a discharge lighting circuit is not less than 0.85, the current demand for the circuit can be calculated from:
- current (A) = (lamp power (W) x 1.8) / supply voltage (V)
- For example, the steady state current demand of a 240 V circuit supplying ten 65 W fluorescent lamps would be: I = 10X65X1.8A / 240 = 4.88A
- Switches for circuits feeding discharge lamps must be rated at twice the current they are required to carry, unless they have been specially constructed to withstand the severe arcing resulting from the switching of such inductive and capacitive loads.

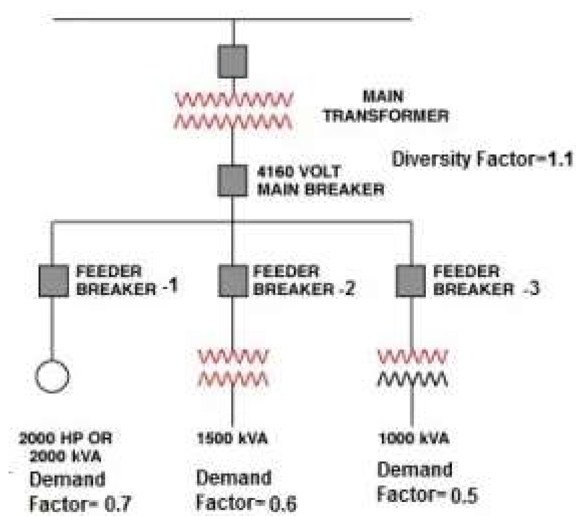
Where to use Demand and Diversity factor:

- There is generally confusion between Demand factor and Diversity factor. **Demand factors should be ideally applied to individual loads and diversity factor to a group of loads.**
- When you talk about ‘diversity’, there are naturally more than one or many loads involved.
- Demand factor can be applied to calculate the size of the sub-main, which is feeding a Sub panel or a fixed load like a motor etc, individual Load.
- Demand factors are more conservative and are used by NEC for service and feeder sizing.
- If the Sub panel have total load is 250 kVA , considering a Demand factor of 0.8, we can size the feeder cable for 250 x 0.8= 200 kVA.
- The Diversity Factor is applied to each group of loads (e.g. being supplied from a distribution or sub-distribution board), size the Transformer.

- Demand factors and diversity factors are used in design. For example, the sum of the connected loads supplied by a feeder is multiplied by the demand factor to determine the load for which the feeder must be sized. This load is termed the maximum demand of the feeder. The sum of the maximum demand loads for a number of sub feeders divided by the diversity factor for the sub feeders will give the maximum demand load to be supplied by the feeder from which the sub feeders are derived.

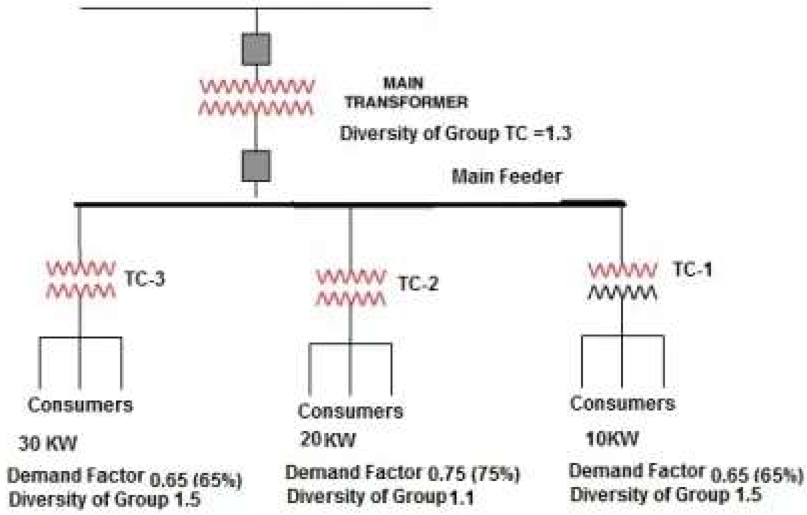
Calculate Size of Electrical Switchgear by Demand & Diversity Factor:

- The estimated electrical demand for all feeders served directly from the service entrance is calculated by multiplying the total connected loads by their demand factors and then adding all of these together. **This sum is divided by the diversity factor (frequently assumed to be unity) to calculate the service entrance demand** which is used to determine ampacity requirements for the service entrance conductors.
- When used Diversity and Demand Factor in an electrical design it should be applied as follows, the sum of the connected loads supplied by a feeder-circuit can be multiplied by the demand factor to determine the load used to size the components of the system.
- The sum of the maximum demand loads for two or more feeders is divided by the diversity factor for the feeders to derive the maximum demand load.
- **Example-1:** Calculate Size of Transformer having following details:



- Feeder Breaker-1 Demand Load= Feeder Breaker-1xDemand Factor.
- Feeder Breaker-1 Demand Load=2000×0.7=1400 KVA
- Feeder Breaker-2 Demand Load= Feeder Breaker-2xDemand Factor.
- Feeder Breaker-2 Demand Load=1500×0.6=900 KVA
- Feeder Breaker-3 Demand Load= Feeder Breaker-3xDemand Factor.
- Feeder Breaker-2 Demand Load=1000×0.5=500 KVA
- Total Feeder Breaker Demand=1400+900+500=2800KVA
- Transformer Demand Load= Total Feeder Breaker Demand / Diversity Factor.
- **Transformer Demand Load=2800/1.1 =2545 KVA**
- If we Calculated Total Load on Transformer without any Demand & Diversity=2000+1500+1000=4500KVA.

- But after Calculating Demand & Diversity Factor Total Load on Transformer =2545 KVA
- **Example-2:** Calculate Size of Main Feeder of Main Transformer having following Details:



- Sum of Maximum Demand of Customer on TC-1 =10 KWx0.65 =6.5 KW
- Sum of Maximum Demand of Customer on TC-2 =20 KWx0.75 =15 KW
- Sum of Maximum Demand of Customer on TC-3 =30 KWx0.65 =19.5 KW
- As Diversity of Consumer Connected on TC-1 is 1.5 so,
- Maximum Demand on TC-1 =6.5 KW/1.5 = 4 KW.
- As Diversity of Consumer Connected on TC-2 is 1.1 so,
- Maximum Demand on TC-2 =15 KW/1.1 = 14 KW
- As Diversity of Consumer Connected on TC-3 is 1.5 so,
- Maximum Demand on TC-3 =19.5 KW/1.5 = 13 KW.
- Individual Maximum Demand on Main Transformer =04+14+13= 31 KW.
- **Maximum Demand on Main Feeder =04+14+13 / 1.3 =24 KW**

Significance of Load Factor and Diversity Factor

- Load factor and diversity factor play an important part in the cost of the supply of electrical energy. Higher the values of load factor and diversity factors, lower will be the overall cost per unit generated.
- The capital cost of the power station depends upon the capacity of the power station. Lower the maximum demand of the power station, the lower is the capacity required and therefore lower is the capital cost of the plant. With a given number of consumers the higher the diversity factor of their loads, the smaller will be the capacity of the plant required and consequently the fixed charges due to capital investment will be much reduced.
- Similarly higher load factor means more average load or more number of units generated for a given maximum demand and therefore overall cost per unit of electrical energy generated is reduced due to distribution of standing charges which are proportional to maximum demand and independent of number of units generated.
- Thus the suppliers should always try to improve the load factor as well as diversity factor by inducing the consumers to use the electrical energy during off peak hours and they may be charged at lower rates for such schemes.