Electrical Power Demand for Buildings And Networks

بحث مقدم من قبل المهندس المجاز

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١. PRELIMINARY DATA

١.١ SCOPE. This discussion provides an introduction to the criteria necessary for the proper selection of electric power sources and distribution systems. It covers preliminary load estimating factors and electrical power sources.

١.٢ LOAD DATA. Before specific electric power sources and distribution systems can be considered, realistic preliminary load data must be compiled. The expected electric power demand on intermediate substations, and on the main electric power supply, shall be calculated from the connected load layout by applying appropriate factors. Determine these factors by load analysis and by combining loads progressively. To combine the loads, start at the ends of the smallest feeders and work back to the Electric power source.
Because all loads must be on a common kilowatt (kW) or kilovolt- ampere (kVA) basis, it is necessary to convert motor horsepower ratings to input kilowatts or kilovolt-amperes before combining them with other loads already expressed in those terms. Preliminary electric power load estimates can be made by using the approximate value of one kilovolt-ampere of input per horsepower (hp) at full load.

١.٣ LOAD ANALYSIS. To determine appropriate load estimating factors, using the tables and factors in this manual as guides to analyze the characteristics of each load. Consider items such as environmental conditions of weather, geographical location, and working hours, as the situation dictates. Notice that when the load densities in $w/m^{٢}$ are used only in preliminary estimates, the demand and load factors will be used in the final designs.

١.٤ TERMINOLOGY. Five terms are essential to the analysis of load characteristics: demand factor, coincidence factor, diversity factor, load factor and maximum demand. These terms are defined below.

١.٤.١ DEMAND FACTOR. The demand factor is the ratio of the maximum demand on a system to the total connected load of the system or

EQUATION: Demand factor = $\frac{\text{Maximum demand load}}{\text{Total load connected}}$

١.٤.٢ 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 or

EQUATION: Coincidence factor = $\frac{\text{Maximum system demand}}{\text{Sum of individual maximum demands}}$

١.٤.٣ DIVERSITY FACTOR. The diversity factor is the reciprocal of the coincidence factor or

EQUATION: Diversity factor = $\frac{\text{Sum of individual maximum demands}}{\text{Maximum system demand}}$

١.٤.٤ LOAD FACTOR. The load factor is the ratio of the average load over a designated period of time, usually ١ year, to the maximum load occurring in that period or

EQUATION: Load factor = $\frac{\text{Average load}}{\text{Maximum load}}$

١.٤.٥ MAXIMUM DEMAND. The maximum demand is the integrated demand for a specified time interval, i.e., ٥ minutes, ١٥ minutes, ٣٠ minutes, or other appropriate time intervals, rather than the instantaneous or peak demand.

٢. ESTIMATION OF LOADS

٢.١ PREPARATION OF LOAD DATA. Load data are generally computed in steps such as:

A) Individual Loads.

B) Area Loads.

C) Activity Loads.

A particular design problem may be limited to step (a), to steps (a) and (b), or may encompass steps (a), (b), and (c). This section outlines each step as a separate entity, dependent only on previous steps for data.

٢.٢ INDIVIDUAL LOADS. Individual loads are those with one incoming service supplying utilization voltage to the premises. In general, these loads would comprise single structures. Large structures could contain more than one function. Under this condition, factors that have been developed and would be used according to tables below.

٢.٢.١ LIGHTING. To eliminate lighting loads, divide a facility area into its significant components by function (for example, office, storage, mechanical, and corridor). Determine the average lighting level and type of light source for each area. Consider requirements for supplementary lighting (for example, floodlighting, security lighting, and special task lighting). Preliminary load estimates may be made based on the following load allowances:

a) ١٠.٧٥ W/m٢ for each ٦٤.٦ lx to ٨٦ lx of incandescent illumination. b) ١٠.٧٥ W/m٢ for each ١٦١.٥ lx to ٢١٥.٣ lx of fluorescent illumination.

c) ١٠.٧٥ W/m٢ for each ١٣٠ lx to ١٩٤ lx of mercury vapor illumination. d) ١٠.٧٥ W/m٢ for each ٢٨٠ lx to ٣٨٧.٥ lx of metal halide illumination.

e) ١٠.٧٥ W/m٢ for each ٣٥٥ lx to ٥٨١.٣ lx of high pressure

sodium Illumination.

٢.٢.٢The lighting power demand can be calculated using the formula:

$P_{lighting} = \Sigma p * A$

Where:

P [W/m^{٢}]: the specific electric power demand of lighting:

Low visual demand: ٥W/m^{٢},

Such functions and rooms would be: storages, WC, machinery rooms, etc.

Intermediate visual demand: ١٠ W/m^{٢},

Such functions and rooms would be: reception, restaurant, hall, mall, corridors.

Mediate visual demand: ١٥ W/m^{٢},

Such functions and rooms would be: offices, kitchen, pay-desk, etc.

High visual demand:

٢٠ W/m^{٢},

Such functions and rooms would be: exhibition rooms, cosmetics, etc.

A [m^{٢}]: sum of floor areas of the rooms.

Summary of Demand Loads(Example):Table ١.١

Equipment	kW	D.F.	Demand KW
Lighting	٥	١	٥
Receptacle Outlets	٢٢.٥	.١	٢.٢٥
Lathe	٧.٥	.٣٣	٢.٤٦
Air Compressor	١٥	٠.٥	٧.٤٦
Fire Pump	١١.٢٥	٠.٠	٠.٠

Diversity Factor for distribution switchboards: Table ١.٢

Number of circuits	Diversity Factor (ks)
Assemblies entirely tested ٢ and ٣	٠.٩
٤ and ٥	٠.٨
٦ to ٩	٠.٧
١٠ and more	٠.٦
Assemblies partially tested in every case choose	١

Diversity Factor for according to circuit function (IEC ٦٠٤٣٩): Table ١.٣

Circuits Function	Diversity Factor (ks)
Lighting	٠.٩
Heating and air conditioning	٠.٨
Socket-outlets	٠.٧
Lifts and catering hoist	
For the most powerful motor	١
For the second most powerful motor	٠.٧٥
For all motors	٠.٨

٢.٢.٣ SMALL APPLIANCE LOADS. Small appliance loads shall include those served by general purpose receptacles. In general, the dividing of areas by function for estimating lighting loads will serve for estimating small appliance loads. The determination of loads requires not only knowledge of the function of an area, but to what extent its occupants use small appliances. For example, an office area demand may average about ١٠.٧٥ W/m٢ but could vary from a low of ٥.٣٨ W/m٢ to a high of ١٦.٢ W/m٢ depending on the specific tasks to be performed. A minimum of ١.١ W/m٢ for auditoriums to a maximum of ٢٧ W/m٢ for machine shops is possible, although the upper limit would occur very rarely. Mechanical spaces in building storage areas and similar spaces in which outlets are provided but infrequently used are usually neglected in computing loads, except for special cases.

Electrical load estimation or power consumption is very important for us as a consultant engineer to design our main switch board (MSB) size or estimate the required power for the building. Most of the time we can't estimate or calculate the actual connected load or power consumption that going to be used by the building owner, especially switch socket outlet, no way to estimate the actual loading unless we know that what type of equipment plug into the switch socket outlet. Therefore, load estimation is important for us to size our MSB see table١.٢ and١.٣.The following load estimation can be use for estimate the connected load.

Socket Outlet

١. **٥A Switch Socket Outlet= ١٠٠W**
٢. **١٣A Switch Socket Outlet= ٢٠٠W**
٣. **١٥A Switch Socket Outlet= ٥٠٠W**
٤. **١٥A Switch Socket Outlet c/w air conditioning starter= ١٠٠٠W**
٥. **١٥A TPN Switch Socket Outlet= ١٥٠٠W**
٦. **٣٠A SPN Switch Socket Outlet= ٢٠٠٠W**
٧. **٣٠A TPN Switch Socket Outlet= ٦٠٠٠W**
٨. **٦٠A SPN Switch Socket Outlet= ٤٠٠٠W**
٩. **٦٠A TPN Switch Socket Outlet= ١٢٠٠٠W**

Isolator:

١. **٢٠A SPN Isolator= ١٥٠٠W**
٢. **٢٠A SPN Isolator c/w air conditioning starter= ١٥٠٠W**

٣. ٢٠A TPN Isolator= ٤٥٠٠W
٤. ٢٠A TPN Isolator c/w air conditioning starter= ٤٥٠٠W
٥. ٣٠A TPN Isolator= ٦٠٠٠W
٦. ٦٠A TPN Isolator= ١٢٠٠٠W
٧. ١٠٠A TPN Isolator= ٢٢٥٠٠W
٨. ٤٥A Cooker Unit= ٣٠٠٠W
٩. ٣٠A Cooker Unit= ٢٠٠٠W

Lighting:

١. Lighting Point (General) for lighting less than ١٠٠W= ١٠٠W
٢. Lighting Point more than ١٠٠W= as specified.

Fan:

١. Wall fan= ١٠٠W
٢. Ceiling Fan= ١٠٠W
٣. Exhaust Fan= ١٠٠W

٢.٢.٤ ELECTRIC POWER LOADS. Electric power loads shall include all loads other than lighting loads and those served by general purpose receptacles and comprise the environmental system electric power requirements and the facility occupancy equipment electric power requirements.

٢.٢.٥ SYSTEM LOSS. A system loss of approximately ٦ percent, based on calculated maximum demand, should be added to the building load.

٢.٢.٦ Maximum Demand for Buildings:

Estimating maximum demand is a topic frequently discussed. Working out how Much power to allow for a building in my experience a very subjective.

Allowing too much power results in additional equipment, increased space Requirements, greater system losses and extra cost. On the other side, not Enough power results in operational problems.

Early in a project power demand is estimated on a w/m٢ basis. Each building needs to be considered on it merits and appropriate allowances worked out (for example a office designed for high end banking clients will require more power

Than a general purpose office). While there are no fixed guidelines it is good to Have some sort of starting point. The table ٢.١ below is something I have put Together as an initial set of demand figures for starting.

POWER DEMAND W/M٢: Table ٢.١

	Lighting		Power	
Space	(W/m٢)	SF	(W/m٢)	SF٢
Atrium - First Three Floors	٦	٠.٨٥	٩	٠.٣
Atrium - Floors (above first ٣)	٢	٠.٨٥	٩	٠.٣
Audience/Seating Area - Convention Centre	٨	٠.٨٥	٥	٠.٣
Audience/Seating Area - Exercise Centre	٣	٠.٨٥	٥	٠.٣
Audience/Seating Area - General	١٠	٠.٨٥	٥	٠.٣
Audience/Seating Area - Gymnasium	٤	٠.٨٥	٥	٠.٣
Audience/Seating Area - Motion Picture Theatre	١٣	٠.٨٥	٥	٠.٣
Audience/Seating Area - Penitentiary	٨	٠.٨٥	٥	٠.٣
Audience/Seating Area - Performing Arts Theatre	٢٨	٠.٨٥	٥	٠.٣
Audience/Seating Area - Religious Buildings	١٨	٠.٨٥	٥	٠.٣
Audience/Seating Area - Sports Arena	٤	٠.٨٥	٥	٠.٣
Audience/Seating Area - Transportation	٥	٠.٨٥	٥	٠.٣
Automotive-Service/Repair	٨	٠.٨٥	٧٢	٠.٦
Bank/Office-Banking Activity Area	١٦	٠.٨٥	٥٤	٠.٦
Classroom/Lecture/Training - General	١٥	٠.٨٥	١٥	٠.٦
Classroom/Lecture/Training - Penitentiary	١٤	٠.٨٥	١٥	٠.٦
Conference/Meeting/Multipurpose	١٤	٠.٨٥	٢٦	٠.٨
Convention Centre-Exhibit Space	١٤	٠.٨٥	٢٦	٠.٨
Corridor/Transition - General	٥	٠.٨٥	١٠	٠.٣
Corridor/Transition - Hospital	١١	٠.٨٥	١٠	٠.٣
Corridor/Transition - Manufacturing Facility	٥	٠.٨٥	١٠	٠.٣
Courthouse - Confinement Cells	١٠	٠.٨٥	٠	٠
Courthouse - Courtroom	٢٠	٠.٨٥	٢٠	٠.٨
Courthouse - Judges' Chambers	١٤	٠.٨٥	٢٠	٠.٨
Dining Area - Bar Lounge/Leisure Dining	١٥	٠.٨٥	١٠	٠.٣
Dining Area - Family Dining	٢٣	٠.٨٥	١٠	٠.٣
Dining Area - General	١٠	٠.٨٥	١٠	٠.٣
Dining Area - Hotel	١٤	٠.٨٥	١٠	٠.٣

Dining Area - Motel	١٣	٠.٨٥	١٠	٠.٣
Dining Area - Penitentiary	١٤	٠.٨٥	١٠	٠.٣
Dormitory-Living Quarters	١٢	٠.٨٥	١٨	٠.٦
Dressing/Locker/Fitting Room	٦	٠.٨٥	١٠	٠.٣
Electrical/Mechanical	١٦	٠.٨٥	١٥	٠.٣
Exterior - Stairways	١٠.٨	٠.٨٥	٠	٠
Exterior - Building Facades (illuminated)	٢.٢	٠.٨٥	٠	٠
Exterior - Building Facades (non-illuminated)	٠	٠.٨٥	٠	٠
Exterior - Canopies/Overhangs	١٣.٥	٠.٨٥	٠	٠
Exterior - Entrances/Inspection Station	١٣.٥	٠.٨٥	٠	٠
Exterior - Loading Areas	٥.٤	٠.٨٥	٠	٠
Exterior - Sales Areas	٥.٤	٠.٨٥	٠	٠
Exterior - Uncovered Parking Area	١.٦	٠.٨٥	٠	٠
Exterior - Walkways (< ٣m wide)	٩.٩	٠.٨٥	٠	٠
Exterior - Walkways (≥٣ m wide)	٢.٢	٠.٨٥	٠	٠
Fire Stations - Engine Room	٩	٠.٨٥	١٥	٠.٣
Fire Stations - Sleeping Quarters	٣	٠.٨٥	١٨	٠.٦
Food Preparation	١٣	٠.٨٥	٣٨٧	٠.٨
Gymnasium/Exercise Centre - Exercise Area	١٠	٠.٨٥	٢٠	٠.٦
Gymnasium/Exercise Centre - Playing Area	١٥	٠.٨٥	١٥	٠.٦
Hospital - Emergency	٢٩	٠.٨٥	٣٦٠	٠.٦
Hospital - Exam/Treatment	١٦	٠.٨٥	٣٦٠	٠.٦
Hospital - Laundry-Washing	٦	٠.٨٥	٣٦٠	٠.٦
Hospital - Medical Supply	١٥	٠.٨٥	٣٦٠	٠.٦
Hospital - Nursery	٦	٠.٨٥	٣٦٠	٠.٦
Hospital - Nurses' Station	١١	٠.٨٥	٣٦٠	٠.٦
Hospital - Operating Room	٢٤	٠.٨٥	٣٦٠	٠.٦
Hospital - Patient Room	٨	٠.٨٥	٣٦٠	٠.٦
Hospital - Pharmacy	١٣	٠.٨٥	٣٦٠	٠.٦
Hospital - Physical Therapy	١٠	٠.٨٥	٣٦٠	٠.٦
Hospital - Radiology	٤	٠.٨٥	٣٦٠	٠.٦
Hospital - Recovery	٩	٠.٨٥	٣٦٠	٠.٦
Hotel/Motel Guest Rooms	١٢	٠.٨٥	١٨	٠.٦
Laboratory	١٥	٠.٨٥	٣٦٠	٠.٦
Library - Card File and Cataloguing	١٢	٠.٨٥	٣٨	٠.٦
Library - Reading Area	١٣	٠.٨٥	٣٢	٠.٦
Library - Stacks	١٨	٠.٨٥	٣٢	٠.٦
Lobby - General	١٤	٠.٨٥	١	٠.٣
Lobby - Hotel	١٢	٠.٨٥	١٨	١

Lobby - Motion Picture Theatre	١٢	٠.٨٥	١٨	١
Lobby - Performing Arts Theatre	٣٦	٠.٨٥	١٨	١
Lounge/Recreation - General	١٣	٠.٨٥	٢	٠.٣
Lounge/Recreation - Hospital	٩	٠.٨٥	٦	٠.٣
Manufacturing - Control Room	٥	٠.٨٥	٧٢	٠.٦
Manufacturing - Detailed Manufacturing	٢٣	٠.٨٥	٧٢	٠.٦
Manufacturing - Equipment Room	١٣	٠.٨٥	٧٢	٠.٦
Manufacturing - High Bay (≥٧.٦ m)	١٨	٠.٨٥	٧٢	٠.٦
Manufacturing - Low Bay (<٧.٦ m)	١٣	٠.٨٥	٧٢	٠.٦
Museum - General Exhibition	١١	٠.٨٥	٦٩	٠.٦
Museum - Restoration	١٨	٠.٨٥	٦٢	٠.٦
Office -Enclosed	١٢	٠.٨٥	٢٨	٠.٨
Office -Open Plan	١٢	٠.٨٥	٢٨	٠.٨
Parking Garage-Garage Area	٢	٠.٨٥	٨	٠.٦
Penitentiary - Confinement Cells	١٠	٠.٨٥	٠	٠
Penitentiary - Courtroom	٢٠	٠.٨٥	٢٠	٠.٨
Penitentiary - Judges' Chambers	١٤	٠.٨٥	٢٠	٠.٨
Police Station - Confinement Cells	١٠	٠.٨٥	٠	٠
Police Station - Courtroom	٢٠	٠.٨٥	٢٠	٠.٨
Police Station - Judges' Chambers	١٤	٠.٨٥	٢٠	٠.٨
Post Office-Sorting Area	١٣	٠.٨٥	٧٢	٠.٦
Religious Buildings - Fellowship Hall	١٠	٠.٨٥	٥	٠.٣
Religious Buildings - Worship Pulpit, Choir	٢٦	٠.٨٥	٥	٠.٣
Restrooms/Toilets	١٠	٠.٨٥	٥	١
Retail Mall Concourse	١٨	٠.٨٥	٤٢	٠.٦
Sales Area (for accent lighting)	١٨	٠.٨٥	٠	٠
Sports Arena - Court Sports Area	٢٥	٠.٨٥	٥	٠.٦
Sports Arena - Indoor Playing Field Area	١٥	٠.٨٥	٥	٠.٦
Stairs	٦	٠.٨٥	٩	٠.٣
Storage Active - General	٩	٠.٦	٦	٠.٣
Storage Active - Hospital	١٠	٠.٦	٦	٠.٣
Storage Inactive - General	٣	٠.٤	٦	٠.٣
Storage Inactive - Museum	٩	٠.٤	٦	٠.٣
Transportation - Air/Train/Bus Baggage Area	١١	٠.٨٥	١٩	١
Transportation - Airport Concourse	٦	٠.٨٥	٢٤	١
Transportation - Terminal Ticket Counter	١٦	٠.٨٥	١٤	١
Warehouse - Fine Material Storage	١٥	٠.٨٥	٥	٠.٦
Warehouse - Medium/Bulky Material Storage	١٠	٠.٨٥	٥	٠.٦
Workshop	٢٠	٠.٨٥	٧٢	٠.٦

٢.٢.٦ DEMAND AND LOAD FACTORS. The demand and load factors for a specific facility will vary with the division of load and hours of usage. Refer to Tables ٢.٢ and ٢.٣ for values that can be applied to determine demand and load factors. Table١.١ is included as a guide and an aid in illustrating the method of determining loads, which are calculated for a particular type of building. The values given are empirical and will vary from activity to activity, and may vary from one facility to another within an activity. Annual hours use of demand must be determined for each case in accordance with methods of operation and characteristics of the installation. Such factors should be Used for quick estimating

Purposes and as a check when a more precise calculation is undertaken.

٢.٢.٥.١ Guides for Demand Factors. For guides on the selection of demand factors, refer to Table ١.١ and ٢.٣.

٢.٢.٥.٢ Guides for Load Factors. Guides for the selection of load factors indicate the need for special considerations refer to Table ٢.٢ and ٢.٣.

٢.٢.٦ LOAD GROWTH. Determine the requirements for load growth for anticipated usage and life expectancy with particular attention to the possibility of adding heavy loads in the form of air conditioning, electric heating, electric data processing, and electronic communication equipment. Before determining the size of service and method of distribution to a facility, an economic analysis shall be made to determine the most feasible way of serving this future load. This analysis shall include the effect on the existing installation if future loads require reinforcing or rehabilitation of the service system.

Demand Factor & Load Factor according to Type of Industries: Table ٢.٢

Type of Industry	Demand Factor	Load Factor	Utilization Factor (DF x LF)
Arc Furnace	٠.٥٥	٠.٨٠	٠.٤٤
Induction Furnace	٠.٩٠	٠.٨٠	٠.٧٢
Steel Rolling mills	٠.٨٠	٠.٢٥	٠.٢٠
Mechanical/ Electrical			
a) Single Shift	٠.٤٥	٠.٢٥	٠.١١
b) Double Shift	٠.٤٥	٠.٥٠	٠.٢٢
Cycle Industry	٠.٤٠	٠.٤٠	٠.١٦
Wire products	٠.٣٥	٠.٤٠	٠.١٤
Auto Parts	٠.٤٠	٠.٥٠	٠.٢٠
Forgings	٠.٥٠	٠.٣٥	٠.١٧
Cold Storage			
a) Working Season	٠.٦٠	٠.٦٥	٠.٣٩
b) Non-Working Season	٠.٢٥	٠.١٥	٠.٠٤
Rice Sheller's			
a) Working Season	٠.٧٠	٠.٨٠	٠.٥٦

b) Non-Working Season	٠.٠٥	٠.٣٠	٠.٠١
Ice Candy Units			
a) Working Season	٠.٥٠	٠.٦٥	٠.٣٢
b) Non-Working Season	٠.٥٠	٠.١٠	٠.٠٥
Ice Factories			
a) Working Season	٠.٨٠	٠.٦٥	٠.٥٢
b) Non-Working Season	٠.٨٠	٠.١٠	٠.٠٨
Cotton Ginning			
a) Working Season	٠.٧٠	٠.٢٥	٠.١٧
b) Non-Working Season	٠.١٠	٠.١٠	٠.٠١
Spinning Mills	٠.٦٠	٠.٨٠	٠.٤٨
Textile Industry	٠.٥٠	٠.٨٠	٠.٤٠
Dyeing and Printing	٠.٤٠	٠.٥٠	٠.٢٠
Ghee Mills	٠.٥٠	٠.٥٠	٠.٢٥
Oil Mills	٠.٧٠	٠.٥٠	٠.٣٥
Solvent Extraction Mills	٠.٤٥	٠.٥٠	٠.٢٢
Plastic	٠.٦٠	٠.٢٥	٠.١١
Soap	٠.٥٠	٠.٢٥	٠.١٢
Rubber (Foot Wear)	٠.٤٥	٠.٣٥	٠.١٦

Distilleries	٠.٣٥	٠.٥٠	٠.١٧
Chemical Industry	٠.٤٠	٠.٥٠	٠.٢٠
Gas Plant Industry	٠.٧٠	٠.٥٠	٠.٣٥
Pain and Colour Factory	٠.٥٠	٠.٤٠	٠.٢٠
Sugar	٠.٣٠	٠.٤٥	٠.١٣
Paper	٠.٥٠	٠.٨٠	٠.٤٠
Flour Mills(Single Shift)	٠.٨٠	٠.٢٥	٠.٢٠
Atta Chakies	٠.٥٠	٠.٢٥	٠.١٢
Milk Plants	٠.٤٠	٠.٨٠	٠.٣٢
Printing Presses	٠.٣٥	٠.٣٠	٠.١٠
Repair Workshops	٠.٤٠	٠.٢٥	٠.١٠
Bottling Plants	٠.٤٠	٠.٣٥	٠.١٤
Radio Stations	٠.٥٥	.٠.٤٥	٠.٢٥
Telephone exchange	٠.٥٠	٠.٩٠	٠.٤٥
Public Water Works	٠.٧٥	٠.٤٠	٠.٣٠
Medical Colleges	٠.٦٠	٠.٢٥	٠.١٥
Hospitals	٠.٢٥	٠.٩٠	٠.٢٢
Nursing Homes	٠.٥٠	٠.٥٠	٠.٢٥
Colleges and Schools	٠.٥٠	٠.٢٠	٠.١٠

Hotels and Restaurants	٠.٧٥	٠.٤٠	٠.٣٠
Marriage Palaces	١.٠٠	٠.٢٥	٠.٢٥

Demand Factor & Load Factor according to Type of Buildings: Table ٢.٣

Individual Facilities	Demand Factor	Load Factor
Communications – buildings	٦٠-٦٥	٧٠-٧٥
Telephone exchange building	٥٥-٧٠	٢٠-٢٥
Air passenger terminal building	٦٥-٨٠	٢٨-٣٢
Aircraft fire and rescue station	٢٥-٣٥	١٣-١٧
Aircraft line operations building	٦٥-٨٠	٢٤-٢٨
Academic instruction building	٤٠-٦٠	٢٢-٢٦
Applied instruction building	٣٥-٦٥	٢٤-٢٨
Chemistry and Toxicology Laboratory	٧٠-٨٠	٢٢-٢٨
Materials Laboratory	٣٠-٣٥	٢٧-٣٢
Physics Laboratory	٧٠-٨٠	٢٢-٢٨
Electrical and electronics systems laboratory	٢٠-٣٠	٣-٧
Cold storage warehouse	٧٠-٧٥	٢٠-٢٥
General warehouse	٧٥-٨٠	٢٣-٢٨
Controlled humidity warehouse	٦٠-٦٥	٣٣-٣٨

Hazardous/flammable storehouse	٧٥_٨٠	٢٠_٢٥
Disposal, salvage, scrap building	٣٥_٤٠	٢٥_٢٠
Hospital	٣٨_٤٢	٤٥_٥٠
Laboratory	٣٢_٣٧	٢٠_٢٥
Dental Clinic	٣٥_٤٠	١٨_٢٣
Medical Clinic	٤٥_٥٠	٢٠_٢٣
Administrative Office	٥٠_٦٥	٢٠_٣٥
Single-family residential housing	٦٠_٧٠	١٠_١٥
Detached garages	٤٠_٥٠	٢_٤
Apartments	٣٥_٤٠	٣٨_٤٢
Fire station	٢٥_٣٥	١٣_١٧
Police station	٤٨_٥٣	٢٠_٢٥
Bakery	٣٠_٣٥	٤٥_٦٠
Laundry/dry cleaning plant	٣٠_٣٥	٢٠_٢٥
K-٦ schools	٧٥_٨٠	١٠_١٥
٧-١٢ schools	٦٥_٧٠	١٢_١٧
Churches	٦٥_٧٠	٥_٢٥
Post Office	٧٥_٨٠	٢٠_٢٥
Retail store	٦٥_٧٠	٢٥_٣٢

Bank	٧٥_٨٠	٢٠_٢٥
Supermarket	٥٥_٦٠	٢٥_٣٠
Restaurant	٤٥_٧٥	١٥_٢٥
Auto repair shop	٤٠_٦٠	١٥_٢٠
Hobby shop, art/crafts	٣٠_٤٠	٢٥_٣٠
Bowling alley	٧٠_٧٥	١٠_١٥
Gymnasium	٧٠_٧٥	٢٠_٤٥
Skating rink	٧٠_٧٥	١٠_١٥
Indoor swimming pool	٥٥_٦٠	٢٥_٥٠
Theater	٤٥_٥٥	٨_١٣
Library	٧٥_٨٠	٣٠_٣٥
Golf clubhouse	٧٥_٨٠	١٥_٢٠
Museum	٧٥_٨٠	٣٠_٣٥

٢.٣ EMERGENCY LOADS. The determination of emergency electric power requirements is based on three types of loads:

a) Minimum essential load,

b) Emergency load for vital operations,

and c) uninterruptible (no-break) load.

When the three categories of emergency electric power requirements have been ascertained, determine where local emergency facilities are required,

where loads may be grouped for centralized emergency facilities, and what loads are satisfied by the reliability of the general system. Base the aforementioned determinations on safety, reliability, and economy, in that order.

٢.٤ AREA LOADS. Area loads consist of groups of individual facility loads served by a subdivision of the electric distribution system. The term "area" applies to the next larger subdivision of an overall distribution system. Demand loads for an area must be known for sizing the distribution wiring and switching, and in a large installation will be required for the design of substations serving the area.

٢.٤.١ GENERAL LOADS. To obtain the general load, add roadway lighting, area lighting, obstruction lighting, and other loads not included in individual facility loads see table ٢.١.

٢.٤.٢ COINCIDENCE FACTOR. Determine the maximum expected demands, taking into consideration whether loads within the area peak at the same or at different times.

٢.٤.٢.١ Electric Power Consumption. In general, areas where large amounts of Electric power are consumed outside the usual ٤٠ working hours a week have a Coincidence factor at the lower end of the range (examples are hospitals, areas operated on two or more shifts, or large barracks type activities). The upper limit of the range is for a ٤٠ hour per week operation; the lower limit is for a ٦٠ hour.

٢.٤.٢.٢. For a small group, determine the coincidence peak load, and to this apply the appropriate intergroup coincidence factor to obtain the coincidence Peak load for the area.

٢.٤.٢.٣ Groups of Loads or Areas:

factor should be in the range ٠.٩٣ to ١.٠٠. If loads of a varying nature (evening loads and daytime loads) are combined, the intergroup

coincidence factor should be in the range of ٠.٧٠ to ١.٠٠. The lower values will occur when the magnitudes of the loads are nearly balanced, and the higher ones when the combined load is predominantly one type.

٢.٤.٣ LOAD GROWTH. In addition to planned expansion, increased application of electric equipment will generate an increase in load. When sizing components, such as transformers or feeders for the area system, consider possible load growth in addition to that included in the determination of individual loads.

٢.٤.٤ SYSTEM LOSSES. Add distribution system losses to estimated area demands. For a good approximation, use ٦ percent of the calculate maximum demand.

٢.٤.٥ EMERGENCY LOADS. Review the overall emergency requirements for the area, based on criteria for the facility or as furnished by the using agency, to determine the following:

a) The emergency loads that may be combined in groups to take advantage of the coincidence factor.

b) The type of distribution system needed for reliability and to economically satisfy at least the less critical emergency load requirements.

This reliability can be provided only if the source of electric power is not the determining factor.

c) Area loads that must be added to individual emergency loads; for example, security lighting and minimum roadway lighting.

٢.٤.٦ EXPANSION. The planned development of the area, as shown on the activity general development map, shall be considered for requirements of future expansion.

٢.٥ ACTIVITY LOADS. Activity loads are loads that consist of two or more area loads served from a single electric power source and an integrated distribution system.

٢.٥.١ GENERAL LOADS. Area loads used for determining activity coincidence demand should be the area coincident demand exclusive of allowance for load growth.

٢.٥.٢ COINCIDENCE FACTOR. Where dissimilar areas, whether residential, administrative, or industrial, are part of an activity, make a careful analysis of the coincidence factor used.

٣. SELECTION OF ELECTRIC POWER SOURCE

٣.١ ELECTRIC POWER SOURCES. The electric power supply for a major development usually will consist of three sources: primary, standby, and emergency (alternate). In many situations the only practicable option is purchasing power from the local electric utility. In other situations, however, there may be alternatives. In addition, some operations cannot tolerate any electric power interruption, thus requiring uninterruptible power supply (UPS) systems.

٣.١.١ PRIMARY. The primary or preferred source should have sufficient capacity to provide for peak electric power demand during normal peacetime operations.

٣.١.٢ STANDBY. The standby source should have enough capacity so that the standby system can supply all of the minimum essential operating electric load of the activity
and, when added to the capacity of the primary source, will provide a combined capacity sufficient to serve the estimated peak demand under mobilization conditions. This "minimum essential operating electric load" is the minimum electric power necessary to support the absolutely essential operations of the activity, with illumination reduced to a bare minimum and with all convenience loads and other loads (such as hospital elevators, except the minimum required for patient and food transportation) suspended. Where major

intermittent loads, such as electric furnaces, electric welders, and wind tunnels, are involved, it is necessary to determine whether concurrent operation of such equipment can be avoided.

٣.١.٣ EMERGENCY. The emergency sources, usually one or more engine-driven, manual, or automatic-starting emergency generators, should have sufficient total capacity to provide the electric power demand for vital operations. Vital operations are those that can tolerate electric power interruption only for relatively short durations. For certain operations, the permissible electric power interruption is as long as ٤ hours, for others it is only ١٠ seconds. The latter condition will require automatic start but the former condition may be manual start. The emergency source should be of sufficient capacity to provide a continuous and adequate supply for vital operations, but should be planned to bear a sound relation to the standby service provided. Vital operations will normally be in two categories:

a) Operations recognized by local, state, or national codes, and b) Operations determined as vital by the major claimant or user.

To qualify as a vital operation, the electric power outages must cause loss of primary missions, thus resulting in disastrous situations or extreme safety hazards as compared to minor disruption and inconvenience. Such vital operations may include, but are not necessarily limited to, communications, ventilation, and lighting of combat operations centers, personnel bomb shelters, anti-aircraft, harbor defenses, industrial processes that might cause explosion if interrupted, hospital surgeries, blood banks, bone banks, iron lungs, and similar operations.

٣.١.٤ UNINTERRUPTIBLE (NO-BREAK) ELECTRIC POWER. An Uninterruptible Power Supply (UPS) system is necessary for certain electronic or other equipment that perform a critical functions and require continuous, disturbance-free electric power to operate properly. This electric power system must, under all conditions, provide regulated electric power to the critical load.

٣.٢ ACCEPTABLE ELECTRIC POWER SOURCES.

٣.٢.١ PRIMARY. The primary source of electric power may be customer-owned generating equipment or one or more feeders from an outside electric power system.

٣.٢.٢ STANDBY. Where the primary source of electric power is customer-owned generation, the standby source may be other customer-owned generation or service supplied over a feeder, or feeders, from an outside electric power supplier. Where the primary source of electric power is from an outside electric power supplier, the standby source may be customer-owned generation or service supplied over a feeder, or feeders, from a different outside electric power supplier or supply from an alternate feeder from the same outside electric power supplier. The alternate feeder must be located at some distance from the normal feeder, and supplied independently of the substation and generating source of the normal feeder. Where this is not feasible, a supply from transmission lines or substations of the outside electric power supplier, which themselves have dual supplies, is an acceptable alternative.

٣.٢.٣ EMERGENCY. Permanently installed, mobile or semi-mobile, manual or automatic starting generating equipment should be provided to supply emergency electric power. Emergency generating capacity should not exceed the minimum required to supply electric power for vital operations, and should be located as close to those loads as practicable. Provisions for normal load growth (١٥ to ٢٠ percent spare capacity) shall be provided As a minimum, the provisions of NFPA ١١٠ Emergency and Standby Power Systems, shall apply.

٣.٢.٤ UNINTERRUPTIBLE (NO-BREAK) ELECTRIC POWER. Permanently installed, automatically operated equipment should be provided to supply uninterruptible electric power. Equipment capacity should not exceed the

minimum required to supply electric power for critical loads, and equipment should be located as close to these loads as practicable. Provision for normal load growth (١٥ to ٢٠ percent spare capacity) shall be provided.

٣.٣ PURCHASED ELECTRIC POWER REQUIREMENTS.

٣.٣.١ ADEQUACY. Determine the capability of the electric utility company to furnish electric power, of the required characteristics, to meet the immediate estimated demand. The capability of the utility to meet the demand should be determined on the best basis available. Ascertain whether or not the utility has enough construction in its program to meet the loads anticipated for the next ٥years.

٣.٣.٢ RELIABILITY. Investigate the history of outages of the contemplated utility company to determine if it can provide the degree of reliability required by the particular installation. The investigation shall include the following items:

a) A ٥-year history of service outages in the area, including:

(١) The time and date of each occurrence
(٢) Duration, time, and date of each restoration
(٣) Cause
(٤) Steps taken to restore service and
(٥) A probability analysis showing the expected number of outages of ١ minute, ٥ minutes, ١٠ minutes, ٣٠ minutes, and ٦٠ minutes.

b) A one-line diagram of the supplier's system, showing the location of all switching equipment, circuit breakers, relaying, and similar components. c) A short circuit study of the system, including interrupting capacities of all switching equipment, time constants, and short circuit currents for both existing and expanded facilities in the area.

d) Voltage regulation, nominal voltage, and normal operating voltage of Supplier's facilities.

e) Climatic and other physical conditions prevailing in the area and on the System that may affect the reliability of service. Some utilities will only supply a minimum of data for items a) to c), and evaluation may be necessary using data available from other installations in the area.

٣.٣.٣ RATES. To take advantage of the lowest available cost of electric energy, compare electric energy rates with estimated maximum demand and consumption. Compare the estimated demand block with prices per kilowatt-hour of other customers served by the same utility company. Choice of either primary or secondary connection shall be based on selection of connection charges and rental of company equipment that provide the maximum advantage. An analysis of rates shall be based on the company's complete tariff covering all types of services. This review will entail comparison of several tariffs that are available on an alternative basis, as well as the general rules and regulations that modify the tariffs.

٣.٣.٥ PRIMARY SUBSTATIONS

٣.٣.٥.١ Voltage. A substation may not be required where the utility company serves energy at ١١ kV or less; distribution may be at this voltage. In some cases, if the loads are large enough, distribution may be done at higher voltage up to a maximum of ٣٣ kV.

٣.٣.٥.٢ Economics. Usually, ownership of main substations serving an activity is determined by engineering and economic factors. Distribution system voltages, as well as amortization costs of substations, should be the controlling factors.

Factor of simultaneity for an apartment block

Some typical values for this case are given in Table ٣.١, and are applicable to domestic consumers supplied at ٢٣٠/٤٠٠ V (٣-phase ٤-wires). In the case of

consumers using electrical heat-storage units for space heating, a factor of ٠.٨ is recommended, regardless of the number of consumers.

Number of downstream consumers	Factor of simultaneity (ks)
٢ to ٤	١
٥ to ٩	٠.٧٨
١٠ to ١٤	٠.٦٣
١٥ to ١٩	٠.٥٣
٢٠ to ٢٤	٠.٤٩
٢٥ to ٢٩	٠.٤٦
٣٠ to ٣٤	٠.٤٤
٣٥ to ٣٩	٠.٤٢
٤٠ to ٤٩	٠.٤١
٥٠ and more	٠.٤٠

Table ٣.١: Simultaneity factors in an apartment block

Example (see Fig. A١):
٥ storeys apartment building with ٢٥ consumers, each having ٦ kVA of installed load.
The total installed load for the building is: ٣٦ + ٢٤ + ٣٠ + ٣٦ + ٢٤ = ١٥٠ kVA
The apparent-power supply required for the building is: ١٥٠ x ٠.٤٦ = ٦٩ kVA.

It is possible to determine the magnitude of currents in different sections of the common main feeder supplying all floors. For vertical rising mains fed at ground level, the cross-sectional area of the conductors can evidently be progressively reduced from the lower floors towards the upper floors.
These changes of conductor size are conventionally spaced by at least ٣-floor intervals.

In the example, the current entering the rising main at ground level is:

$$\frac{150 \times 0.46 \times 10^3}{400\sqrt{3}} = 100A$$

the current entering the third floor is:

$$\frac{(36+24)\times 0.63\times 10^3}{400\sqrt{3}} = 55A$$

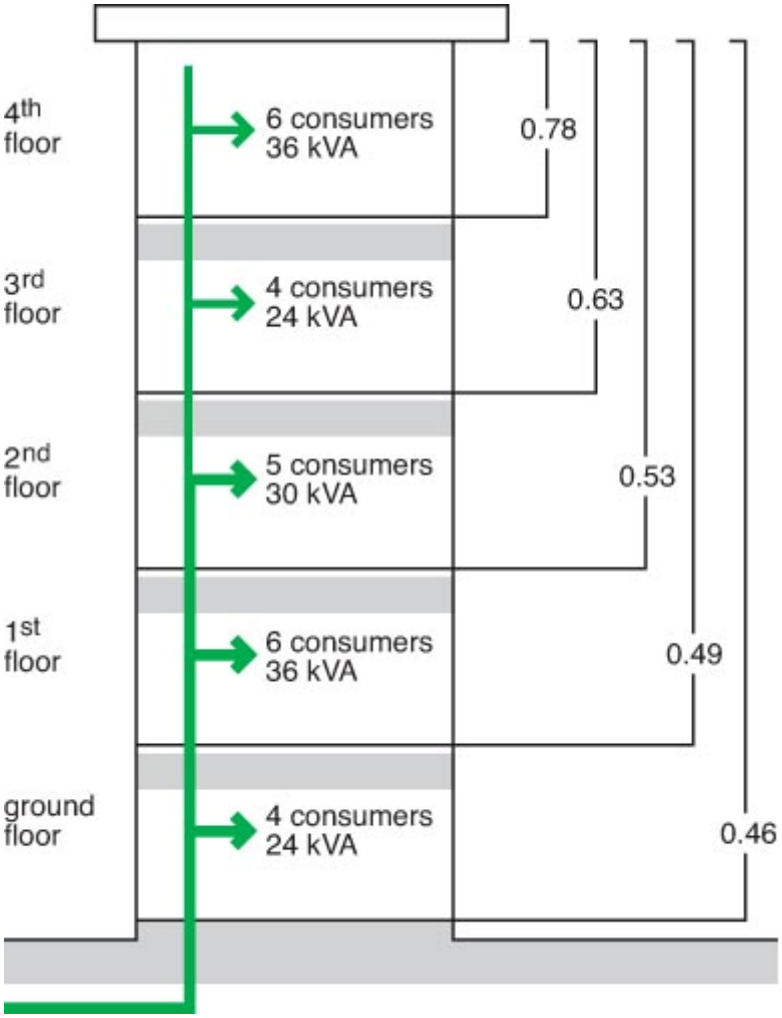

Fig. A ١: Application of the factor of simultaneity (ks) to an apartment block of ٥ storeys.

Factor of simultaneity for distribution switchboards

Table ٣.٢ shows hypothetical values of ks for a distribution board supplying a number of circuits for which there is no indication of the manner in which the total

load divides between them.
If the circuits are mainly for lighting loads, it is prudent to adopt ks values close to unity.

Number of circuits	Factor of simultaneity (ks)
٢ and ٣	٠.٩
٤ and ٥	٠.٨
٦ to ٩	٠.٧
١٠ and more	٠.٦
Assemblies partially tested in every case choose	١.٠

Table ٣.٢: *Factor of simultaneity for distribution boards (IEC ٦١٤٣٩)*

Factor of simultaneity according to circuit function: Table ٣.٣

Ks factors which may be used for circuits supplying commonly-occurring loads are shown in Table ٣.٣.

Circuit function		Factor of simultaneity (ks)
Lighting		١
Heating and air conditioning		١
Socket-outlets		٠.١ to ٠.٢
Lifts and catering hoist	▪ For the most powerful motor ▪ For the second most powerful motor ▪ For all motors	١ ٠.٧٥ ٠.٦٠