

## BASIC ELECTRICAL SUPPLY AND LIGHTING CHARACTERISTICS OF BUILDINGS



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### ABSTRACT

### Keywords:

Electricity,  
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Artificial lighting,  
Natural lighting

The article talks about types of utility-household demand in the field of provision and service of electricity consumption of buildings. The use of electricity as a means of heating, primarily due to the high cost of transporting fuel over long distances, planning and normalizing the demand for electricity requires the study of the mode of operation of individual consumers of electricity receivers and the load demand. In addition to the purpose of the building, the interior planning and volume dimensions, as well as the interior design, should be taken into account in providing light. However, proper lighting of workplaces plays an important role in both organizing the work routine and increasing the utility factor. Using both natural and artificial means as illuminators is one of the characteristics of the modern era. Currently widely used LED lamps are very useful both in terms of economy and for creating a decorative image. Depending on the type of lighting devices, they are divided into groups according to the lighting feature. Each of these types has its own characteristics.

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## BİNALARIN TƏMƏL ELEKTRİK TƏMİNATI VƏ İŞIQLANDIRMA XÜSUSİYYƏTLƏRİ



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### Açar sözlər:

Elektrik enerjisi,  
Enerji istehlakı,  
İşıqlandırma,  
Elektrik təchizatı,  
Elektrik panelləri,  
Süni işıqlandırma,  
Təbii işıqlandırma

### ANNOTASIYA

Məqalədə binaların elektrik enerjisi istehlakının təminatı və xidmət sahəsində kommunal-məişət tələbatı növlərindən bəhs olunur. Elektrikdən, ilk növbədə, yanacaqın uzun məsafələrə daşınmasının baha başa gəlməsi ilə əlaqədar olaraq qızdırıcı vasitə kimi istifadə edilməsi, elektrik enerjisinə tələbatın planlaşdırılması və normallaşdırılması elektrik enerjisi qəbuledicilərinin fərdi istehlakçıların iş rejiminin və yük tələbatının öyrənilməsinə tələb edir. İşığın təmin edilməsində binanın təyinatı ilə yanaşı, daxili planlaşdırma və həcm ölçüləri, həmçinin daxili dizayn da nəzərə alınmalıdır. Bununla belə, iş yerlərinin düzgün işıqlandırılması həm iş rejiminin təşkili, həm də faydalılıq əmsalının artırılmasında vacib rol oynayır. İşıqlandırıcılar olaraq həm təbii, həm də süni vasitələrdən istifadə etmək müasir dövrün xüsusiyyətlərindən biridir. Hazırda geniş istifadə olunan LED lampalar həm qənaət baxımından, həm də dekorativ görüntü yaratmaq üçün çox faydalıdır. İşıqlandırma cihazlarının növündən asılı olaraq, onlar işıqsaçma xüsusiyyətinə görə qruplara bölünürlər. Bu növlərin hər birinin özünəməxsus cəhətləri vardır.

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## ОСНОВНЫЕ ХАРАКТЕРИСТИКИ ЭЛЕКТРОСНАБЖЕНИЯ И ОСВЕЩЕНИЯ ЗДАНИЙ



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### Ключевые слова:

Электроэнергия,  
Энергопотребление,  
Освещение,  
Электроснабжение,  
Электрошиты,  
Искусственное  
освещение,  
Естественное  
освещение

### АННОТАЦИЯ

В статье излагается о видах коммунально-бытового спроса в сфере обеспечения и обслуживания электропотребления зданий. Использование электроэнергии в качестве средства отопления, прежде всего, в связи с высокой стоимостью транспортировки топлива на большие расстояния, планирование и нормирование спроса на электроэнергию требует изучения режима работы отдельных потребителей, а также электроприемников и их нагрузки. Помимо назначения здания при освещении следует учитывать внутреннюю планировку и размеры объема, а также дизайн интерьера. Однако правильное освещение рабочих мест играет важную роль как в организации рабочего режима, так и коэффициента полезности. Использование как естественных, так и искусственных средств в качестве осветителей является одной из особенностей планировки современного строительства. Широко используемые в настоящее время светодиодные (LED) лампы очень полезны как с точки зрения экономии, так и для создания декоративного образа. В зависимости от типа осветительных приборов их разделяют на группы по особенностям освещения. Каждый из этих типов имеет свои особенности.

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## ***1.Introduction***

Electricity consumption of buildings is divided into categories such as household demand of people and utility-household demand in the service sphere. The power of electricity consumption and consumer characteristics in the residential sector is determined, first of all, by the level of electrification of household processes.

The first level of electrification involves the use of lighting and household appliances of various purposes. That is, cultural-household (radio receivers, televisions, tape recorders, etc.), household (washing machine, sewing machines), devices for food processing and storage (refrigerators, universal kitchen machines; toaster, microwave oven, mixer, etc.), sanitary-hygiene devices (electric heaters, hair dryers, electric shavers, etc.).

In the first stage of electrification, gas hobs are used for cooking. Portable electric hobs and cooking cabinets can also be partially used for this purpose. In this case, heating and hot water supply are provided from local heating devices or centralized heat supply devices.

Mobile electric heating devices (reflector, electric stove-fireplace, heating fans, electric oil radiator, etc.) are sometimes used as an additional heat source.

In addition to the first stage, the second stage of electrification involves the installation of electric plates for cooking in apartments. In this case, there is no need to use fuel directly in the household. Heating and hot water supply systems are provided from centralized heat supply sources.

The 3<sup>rd</sup> stage of electrification, or the full electrification of the household, involves the supply of energy demand apartments, including all heating and hot water supply, with stationary electric heating and electric water heating devices.

The modern level of electrical supply of apartments can be characterized as the initial stage of the transition to the 2<sup>nd</sup> stage.

## ***2.Energy consumption***

The widespread distribution of electric plates in households is also carried out in the regions, primarily due to the higher cost of long-distance transportation of fuel. Modern residential buildings also have a large number of common building electrical receivers. These include the garbage chamber of the stairwell, technical basement and attic, the lighting devices of the elevator machine room and shaft, the power unit of the elevator electric motor, ventilation systems, water supply pumps for housekeeping and fire extinguishing.

In the public sector, there are public buildings, offices and communal-household enterprises that have a large number of consumer groups and are relatively evenly distributed in residential areas. Lighting processes, which make up 30÷40% of the total electricity consumption of these enterprises, and operation of various electrical devices (40÷50%) form. In recent years, the electric loads have increased significantly due to the use of heating equipment (electrified kitchens) in the process of preparing food in catering establishments.

Planning and rationing of the demand for electricity is based on the study of the operating mode and load demand of individual consumers of electricity receivers. The change of the load in a period of time (during the day, month, year) is called the regime, and the interpretation of its graph is called the power graph. In world practice in developed countries, the construction of energy-efficient tasks and structures is a mandatory requirement for each designed facility. Moreover, in recent years, the practice of assessing (certifying) projects for energy efficiency, reducing negative impacts on the environment and improving the quality of the human environment has become widespread. [Dobromirov et al.]

For the individual load schedule, individual electricity receivers are distinguished as consumers, and in the case of a group, it is distinguished as different groups of consumers for a group or joint electricity receivers.

At present, the residential apartment is considered as important for normalizing the electricity demand of residential buildings. The specific indicator of the electricity demand of an apartment is calculated depending on the installed power of electric receivers, the degree of density of apartments, the demand factor, the time of use of installed and calculated power. [Table 1]

If gas and electric stove equipment are connected in the apartment, the load at the entrance of the apartment is accepted as 3÷5 kW. The average level of demand for electricity in modern houses with a gas stove is assumed to be 800÷1100 kWh/year. The level of annual demand for electricity in apartments connected to electrical panels - electricity consumption - increases to 1900÷2200 kWh/year.

**Table 1.**

*Calculation of electrical loads of apartments according to the current level of density of electrical household appliances.*

<b>Electrical receivers</b>	<b>P<sub>cib</sub>, W</b>	<b>k<sub>t</sub></b>	<b>density factor</b>	<b>P<sub>qoy</sub>, W</b>	<b>P<sub>maks</sub>, W</b>	<b>T<sub>maks</sub>, hour</b>	<b>W, kVt·h</b>
Lighting devices	400	0,5	1,0	400	200	2000	400
Radio receiver	75	0,5	0,75	45	28	750	21
Televisions	160	0,6	0,8	128	77	1100	85
Refrigerators	140	1	0,7	100	100	2550	255
Washing machines	350	0,1	0,65	230	23	1000	23
Vacuum cleaners	400	0,1	0,2	80	8	1200	10
Irons	750	0,1	0,9	700	700	2000	180
Other devices	800	0,15	0,15	120	18	2000	360
Total (apartment with gas stove)	3070	-	-	1868	520	-	970
Electric battery	5100	0,1	1	5100	510	-	1100
Apartment with total electric plate	8175	-	-	-	1030	-	2070

40÷50 kWh/year is accepted for each resident in the rounded report of the high-rise residential electricity consumption - specific electricity consumption.

The parameters of the network elements are the conductivity of the power lines, as well as the parameters of the transformer, active and inductive resistance. The value of these parameters practically depends only on the physical properties of the network elements, the way they are connected to each other and their constructive implementation. A calculation coefficient is included in the equation that determines the dependence between the

parameters of the network elements and the mode parameters. The ratio of the mode parameters for the elements of the three-phase electrical system is determined as:

Active power, kV·A.

$$P = \sqrt{3} \cdot I \cdot U \cdot \cos \phi$$

Reactive power, kV· A.

$$Q = \sqrt{3} \cdot I \cdot U \cdot \sin \phi$$

Full power, kV·A.

$$S = \sqrt{3} \cdot I \cdot U$$

As well as,

$$S = \sqrt{P^2 + Q^2}$$

$$Q = P \cdot \operatorname{tg} \phi$$

Here: I-line current loads, A;

U- line voltage, kV;

$\phi$ - is the phase shift coefficient between the current vector and the voltage vector.

Active power is determined by the sum of the joint loads of consumers. The active energy associated with it is converted into irreversible mechanical, thermal, radiation and chemical energy processes in consumers' receivers.

Reactive power is used to create a changing electromagnetic field in electric motors, transformers, and transmission lines. Reactive energy is collected in alternating magnetic and electric fields of current receivers and returns back to the energy source. This energy shift in the line, which is repeated every quarter cycle, creates a phase shift angle -  $\phi$  between current and voltage. The cos of the phase shift angle is called the power factor.

Absolute or assumed power gives an idea of the upper limit of active power in electrical installations and networks. The power of power plant generators, transformers, electrical networks and devices is limited by the maximum allowable current passing through the electrical circuit of the corresponding devices. Accordingly, the reduction of the power factor or the increase of the reactive load leads to the reduction of the active power of the system, as a result of which the use of power plants and all other elements of the power supply system becomes difficult.

The active resistance of wires and cables depends on the material, cross-section and linear length of the wire. It is calculated by the following formula:

$$R = r_0 \cdot l$$

Here: R - active resistance of the line, Om;

$r_0$  - specific active resistance of the line, Om/km;

l - length of the line, km.

### **3. Lighting system**

Building lighting is one of the important systems. Because up to 90% of the information that comes to our consciousness about the external world is obtained through the eyes.

Occupancy detection and daylight harvesting together with the users' visual preference can maximize the energy-saving across an LED lighting system in buildings. [Shankar, Krishnasamy, & Babu, 2020] In order to maximize daylight harvesting, conventional building facades can be replaced with semi-transparent BIPV as the skin of the building. BIPV modules hold the potential of turning an energy thirsty building into an on-site clean energy generator [Husain, Hasan, Shafie, Hamidon, & Pandey, 2018] which also reduces the transportation losses and there by the cost of electricity. [Economic analysis of BIPV systems, 2020]

Building-integrated photovoltaics (BIPV) are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. [Shankar, Krishnasamy, & Babu, 2020]

Lighting of buildings and workplaces has a significant impact on visual organs and labor productivity. For example, we can say that it is possible to increase productivity by 25-30% due to the improvement of indoor lighting in production areas. Lighting at a sufficient level is one of the vital conditions for protecting people's vision. Therefore, the lighting standards are determined and standardized depending on the purpose and characteristics of the works performed in various buildings in the construction regulations. The necessary level of lighting is achieved by installing windows, lighting chandeliers and lanterns.

Properly designed artificial lighting allows to increase the level of living, comfort and labor productivity, and to improve the quality of the product.

The main requirements in the arrangement of lighting are the following;

- lighting should be regular, sharp shading should not be allowed.
- there should be a certain contrast between the viewed object and the background.
- lighting should be sufficient for quick and easy selection of the work object.
- the light source should not create a spot on the viewed object
- the light source should not dazzle the eyes.
- the level of illumination of working surfaces should not change over time.

Lighting of buildings can be natural, artificial and combined.

#### ***4.Natural lighting***

Natural lighting has a great biological and psychological effect on a person, it creates a feeling of connection with nature and calms the nervous system. Light strengthens the activity of the whole organism and raises the tone. When there is no natural light for a long time, it has a boring effect on people and depresses their spirit. Therefore, accommodation and recreation. Also, industrial sanitary norms require natural lighting in all residential, administrative, auxiliary and domestic rooms. [Khairi, 2021]

There is also a lack of natural lighting in terms of lighting techniques. So, natural lighting depends on the time of year and day; Depending on the geographical location of the region, the reflective properties of the surfaces (land, greenery, buildings) at the window door can vary greatly, individual workplaces are irregularly illuminated, etc. [Carletti, Cellai, Pierangioli, & Scieurpi, 2017]

Natural lighting is done in three ways.

- a) side lighting (window lighting)
- b) top lighting (chimney lighting)
- c) top and side lighting

#### ***5.Artificial lighting***

When natural lighting is not enough, artificial lighting is applied. Artificial lighting is divided into general and combined lighting systems. When it is required to regularly illuminate the entire area of the interior rooms of buildings, a general lighting system is applied. A joint lighting system is used when it is necessary to create a high level of illumination on work surfaces. According to its purpose, artificial lighting is divided into 5 types: working, duty, emergency, evacuation and guard. [Castanheira, Souza, & Fortes, 2015]

In the absence or lack of natural lighting in buildings and open areas, lighting that ensures the normal course of work, as well as the safe movement of people and traffic, is called working lighting.

Lighting during non-working hours is called duty lighting, and lighting required to continue work when working lighting fails due to an accident is called emergency lighting. As a result of sudden failure of working lighting, emergency lighting should be applied in case of danger of fire, explosion, poisoning, damage, disruption of technological process or communication node, water-gas supply systems.

Evacuation lighting is organized in buildings and halls with more than 50 employees in order to safely leave the building when the lighting fails. At night, the lighting installed on the perimeter of the guarded area is called sentry lighting.

In residential and industrial buildings, the minimum illumination of the working area, and especially of working surfaces, is normalized depending on the degree of accuracy of work, the contrast of the object with the background, the nature of the background, the type of light source and lighting system. Lighting of living, public, administrative, assistant, household rooms, as well as workplaces located outside the building, for example, 100 lk in living rooms, 300 lk in classrooms, 75-50 lk in sanitary-household rooms, 150-75 lk in the vestibule, 75...50 in stairs. etc. based on sanitary standards.

As we mentioned, the artificial lighting norm of buildings and facilities is provided in the regulations depending on the purpose of the building. According to the valid Construction Norms and Rules, the indoor lighting norms are classified in the following tables [Table 2; 3].

**Table 2.**  
*Lighting norms of interior rooms of residential buildings*

<b>№</b>	<b>Illuminated object</b>	<b>Average brightness indicator <math>E_{or}</math>, lk</b>
1	Children's room	200
2	Living rooms and kitchen	150
3	Common rooms	150
4	Corridor and sanitary junctions	50
5	Vestibule	30
6	Floor corridors and elevator halls, stairs and stairwells	20

**Table 3.**  
*Lighting norms of interior rooms of administrative buildings*

<b>№</b>	<b>Illuminated object</b>	<b>Average brightness indicator <math>E_{or}</math>, lk</b>
1	Design halls and rooms, design bureaus	500
2	Analytical laboratories	500
3	Computer and reading rooms	400
4	Laboratories: organic and inorganic chemistry, thermal, physical, photometric, mechanical and radiometric, electronic devices	400
5	Offices. Cabinet and study rooms	300
6	Rooms for visitors and expeditions	300
7	Conference halls, meeting and assembly halls	200
8	Recreation, backroom and foyers	150
9	Archive and book storage halls	75



## **6. Lighting**

In addition to the purpose of the building, the internal planning and volume dimensions, as well as the interior design, are taken into account in providing light.

In most cases, even lighting of the rooms is required. However, it should not be overlooked that proper lighting of workplaces is an important issue. In many cases, as a result of improper compliance with the norms, the level of illumination of the whole building may be 2-3 times less than the norm. The correct solution of this issue is achieved depending on the purpose of that building and facility and by the application and placement of certain types of illuminators provided for in the project of the building and facility. [Lin, Min, Lasers, & Hsu, 2013]

Incandescent, luminescent and LED electric lamps are used as artificial light sources. Incandescent lamps are designed for nominal voltages of 127 and 220 V and are produced in 15...1500 W power. Incandescent lamps have several advantages; their operation and production are simple, they do not require additional structures to connect to the network, they work silently, they start instantly. However, they also have environmental deficiencies.

Incandescent lamps have a low light output (7...20 lk/watt), a relatively short working life (up to 1000 hours), they are not economical, and because the red-yellow rays occupy the main place in their spectrum, they prevent the quality of some work.

Luminescent lamps (gas-discharge lamps) have light characteristics that fully meet hygienic requirements. In these lamps, the radiation of the optical spectrum is caused by electric discharge in the environment of inert gases with metal vapor. These lamps have a working life of up to 1400 hours and a light output of 100 lm/w, so they are more economically efficient. The disadvantage of these lamps is the pulsation of the light stream, the fact that they are not directly connected to the electrical network, but through a special starting device, and that their application is limited in fire-explosive and low-temperature environments.

Led lamps (Light Emitting Diode). LED lamps are used to reduce energy consumption and provide brighter and brighter light. A variety of bulbs with different color shades and different luminance powers are easily available. LED lamp models reduce energy consumption by up to 80% compared to classic lamps. Led lamps are widely used both in terms of economy and to create a decorative image.

LED lights that can be used in different places appear in many places in our daily life. As an example, we can show different types of LED lamp models at home, at work, in office conditions, in the lighting of streets, yards and building facades.

Electric lamps equipped with a special fixture are called illuminants. The task of the armature is to direct the flood of light to the working surfaces, to protect the eyes from the dazzling effect of the lamp, to protect the lamp from mechanical damage and pollution. In the industry, fixtures for incandescent lamps with a power of 60...1000 W, as well as fluorescent lamps with a power of 40 and 80 W are produced.

There are 2 types of lighting devices: for indoor and outdoor lighting. They are also divided into 3 groups according to the light scattering property.

Reflector lighting devices direct at least 90% of the light stream upwards to the ceiling. This type of lighting eliminates glare and sharp shading, but is rarely used because it is not economical.

Diffused light devices direct the flood of light to both hemispheres in approximately equal amounts.

Luminescent and LED lamps are flat light devices. Here, a shielding net, transparent plastic or glass, and light emitters are used to limit glare.

Multi-lamp luminescent illuminators are widely used in the lighting of production rooms. Open-type illuminators are used for lighting production rooms with low dust and normal humidity, and closed-type illuminators (with dust and moisture protection structure)

are used in very dusty and humid rooms. Explosion-proof devices are used in the lighting of explosion-hazardous rooms.

It is convenient to place incandescent lamps on the corners of the square in the room plan. It is recommended to place fluorescent lamps in rows parallel to the walls and windows. In the lighting of open areas, projector lighting is used in all cases where conventional illuminators cannot be installed due to the conditions of the work performed on the illuminated surfaces.

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