МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
КАФЕДРА КОМП’ЮТЕРНО-ІНТЕГРОВАНИХ КОМПЛЕКСІВ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
Синєглазов В.М.
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ДИПЛОМНА РОБОТА
(ПОЯСНЮВАЛЬНА ЗАПИСКА)
ВИПУСНИКА ОСВІТНЬО-КВАЛІФІКАЦІЙНОГО РІВНЯ
“МАГІСТР”

ТЕМА: АВТОМАТИЗОВАНА СИСТЕМА АВТОНОМНОГО ЕНЕРГОЗАБЕЗПЕЧЕННЯ РОЗУМНОГО ДОМУ ПІДВИЩЕНОЇ НАДІЙНОСТІ

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Київ 2020

EDUCATION AND SCIENCE MINISTRY OF UKRAINE
NATIONAL AVIATION UNIVERSITY
DEPARTMENT OF COMPUTER-INTEGRATED COMPLEXES

ADMIT TO DEFENSE
Head of department
Viktor M. Syneglazov
“____”______________ 2020

MASTER’S THESIS
(EXPLANATORY NOTES)

GRADUATE OF EDUCATION AND QUALIFICATION LEVEL
“MASTER”

THEME: AUTOMATIZED SYSTEM OF AUTONOMOUS POWER SUPPLY OF SMART HOUSE OF INCREASED RELIABILITY

Executor: ________________ Pozyvailo M. V.

Supervisor: ________________ Sergeyev I. Y.

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Kyiv 2020

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет аеронавігації, електроніки та телекомунікацій
Кафедра авіаційних комп’ютерно-інтегрованих комплексів
Спеціальність: 151 «Автоматизація та комп'ютерно-інтегровані технології»

ЗАТВЕРДЖУЮ
Завідувач кафедри
_________ В. М. Синєглазов
«______»___________2020 р.

ЗАВДАННЯ
на виконання дипломної роботи

Ім’я студента: Позивайло Максим Віталійович

1. **Тема дипломної роботи:** «Автоматизована система автономного енергозабезпечення розумного дому підвищеної надійності» затверджена наказом ректора від « » вересня 2020 р. № /ст..

2. **Термін виконання роботи:** з 05.10.2020 до 23.12.2020.

3. **Вихідні дані до роботи:** застосувати наукові, інженерно-технічні та енергоефективні підходи, щодо забезпезпечення автоматизованої системи автономного енергозабезпечення розумного дому підвищеної надійності. Врахувати умови, способи та методи забезпечення експлуатаційних характеристик системи автономного енергозабезпечення.

4. **Зміст пояснювальної записки:** 1. Огляд існуючих рішень; 2. Технологія розумного будинку; 3. Аналіз сучасного стану та напрямів розвитку автономних систем електропостачання; 4. Розробка системи управління будівлею; 5. Охорона праці; 6. Охорона навколишнього середовища.

5. **Перелік обов'язкового графічного (ілюстративного) матеріалу**:
1. Структурна схема системи управління будівлею; 2. Стандартна система автономних систем електропостачання; 3. Структурна схема в управлінні будівлею системи автономного енергозабезпечення; 4. Алгоритм роботи системи;

6. **Календарний план-графік**

№ пор.	Завдання	Термін виконання	Відмітка про виконання
1.	Отримання завдання	05.10-12.10.2020	
2.	Формування мети та основних завдань дослідження	13.10-25.10.2020	
3.	Аналіз типів та призначень існуючих автономних систем.	26.10-09.11.2020	
4.	Аналіз існуючих систем управління розумного дому	12.11-19.11.2020	
5.	Розробка структури системи автономного енергозабезпечення	20.11-27.11.2020	
6.	Розробка програмного та апаратного забезпечення автоматизованої системи	28.11-05.12.2020	
7.	Оформлення пояснювальної записки	06.12-12.12.2020	
8.	Підготовка презентації та роздаткового матеріалу	13.12-22.12.2020	

7. Консультанти з окремих розділів

Розділ	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
Охорона праці	к.б.н., доцент, Коновалова О.В.		
Охорона навколишнього середовища	к.т.н., професор, Фролов В.Ф.		

8. **Дата видачі завдання:** “05” жовтня 2020 р.

Керівник дипломної роботи ____________________ І.Ю. Сергеєв
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Завдання прийняв до виконання ____________________ М.В. Позивайло
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NATIONAL AVIATION UNIVERSITY
Faculty of Air Navigation, Electronics and Telecommunications
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The specialty: 151 "Automation and computer-integrated technologies"

APPROVED BY
Head of department
________ Victor M. Sineglazov
"_____" _______________ 2020

Graduate Student's Diploma Thesis Assignment

Student's name: Maksym Pozyvailo

1. **The thesis title:** «Automatized system of autonomous power supply of smart house of increased reliability» " was approved by the Rector's order of "_____" September 2020 № /ст.

2. **The thesis to be completed between:** from 05.10.2020 to 23.12.2020

3. **Output data for the thesis:** to apply scientific, engineering and energy-efficient approaches to ensure an automated system of autonomous energy supply of a smart home of high reliability. Take into account the conditions, methods and techniques of ensuring the operational characteristics of the autonomous energy supply system.

4. **The content of the explanatory note (the list of problems to be considered):** 1. Overview of existing solutions; 2. Smart home technology; 3. Analysis of the current state and directions of development of autonomous power supply systems; 4. Development of a building management system; 5. Labour protection; 6. Environmental protection.

5. **The list of mandatory graphic materials:** 1. Block diagram of the building management system; 2. Standard system of autonomous power supply systems; 3. Block diagram in the management of the building of autonomous energy supply systems; 4. Algorithm of system operation

6. **Planned schedule:**

№	**Task**	**Execution term**	**Execution mark**
1	Otrimannya zavdannya	05.10-12.10.2020	
2	Formation of Meta and Basic Establishments	13.10-25.10.2020	
3	Analysis of types and characteristics of autonomous systems.	26.10-09.11.2020	
4	Analysis of operating control systems for a smart home	12.11-19.11.2020	
5	Development of the structure of the autonomous power supply system	20.11-27.11.2020	
6	Development of software and hardware security of an automated system	28.11-05.12.2020	
7	Execution of an explanatory note	06.12-12.12.2020	
8	Preparation of presentation and distribution material	13.12-22.12.2020	

7. **Special chapters' advisors**

Chapter	Advisor (position, name)	Date, signature	
		Assignment issue date	Assignment accepted
Labor protection	Ph.D, Associate Professor, Konovalova O.V.		
Environmental protection	Ph.D, Associate Professor, Frolov V.F.		

8. Date of task receiving: "05" October 2020

Diploma thesis supervisor ______________ Igor Y. Sergeev
(signature)

Issued task accepted ________________ Maksym V. Pozyvailo
(signature)

РЕФЕРАТ

Пояснювальна записка до дипломної роботи " Автоматизована система автономного енергозабезпечення розумного дому підвищеної надійності ", що містить: 108 сторінок, 28 рисунків і 32 посилань.

Ключові слова: COMBINED POWER SUPPLY SYSTEM, RENEWABLE SOURCES, CONTROL SYSTEM, SMART HOME, MONITORING AND CONTROL OF ELECTRICAL APPLIANCES, SMART SOCKETS, BLUETOOTH LOW ENERGY.

Метою диплома є розробка науково-технічних передумов побудови автономних джерел енергії системи електропостачання із заданими функціональними властивостями враховуючи характер електропостачання і закономірності надійнісно-вартісних характеристик для підвищення надійності та ефективності автономного електропостачання. Підвищення енергетичної ефективності автономних систем електропостачання за умови використання відновлюваних джерел енергії.

Поставлена мета вимагає розв’язання таких задач:

- провести аналіз існуючих структур побудови автономних систем електропостачання, особливостей їх функціонування та взаємозв’язку з системою централізованого електропостачання;
- довести можливість практичного застосування щодо функціонування комбінованої автономної системи електропостачання для оцінки енергоефективності з використанням генеруючих установок ВДЕ;
- запропонувати варіант оптимізованої структури автономної системи електропостачання, що підвищує енергетичну ефективність її функціонування і забезпечує надійне електропостачання груп споживачів.
- обґрунтувати техніко-економічні аспекти впровадження автономних систем електропостачання груп споживачів.

Об'єктом дослідження є автоматизована система енергозабезпечення «Розумний будинок».

Предметом дослідження є визначення взаємозв'язку між системою енергозабезпечення і системою розумного дому.

Методологічні засади базуються на сучасних методах моделювання та програмування мікропроцесорів.

ABSTRACT

The Explanatory note to the thesis "Automated system of autonomous power supply of a smart home of high reliability", contain: 108 pages, 28 figures and 32 links.

Keywords: COMBINED POWER SUPPLY SYSTEM, RENEWABLE SOURCES, CONTROL SYSTEM, SMART HOME, SERVER, MONITORING AND CONTROL OF ELECTRICAL APPLIANCES, SMART SOCKETS, BLUETOOTH LOW ENERGY.

The purpose of the diploma is to develop scientific and technical prerequisites for the construction of autonomous energy sources of the power supply system with specified functional properties, taking into account the nature of power supply and patterns of reliability and cost characteristics to increase reliability and efficiency of autonomous power supply. Improving the energy efficiency of autonomous power supply systems using renewable energy sources.

This goal requires the following tasks:

- to analyze the existing structures for the construction of autonomous power supply systems, the peculiarities of their operation and the relationship with the centralized power supply system;

- to prove the possibility of practical application of the operation of a combined autonomous power supply system for energy efficiency assessment using renewable energy generating units;

- to offer a variant of the optimized structure of the autonomous power supply system, which increases the energy efficiency of its operation and provides a reliable power supply to consumer groups.

- substantiate the technical and economic aspects of the introduction of autonomous power supply systems for consumer groups.

The object of study is the automated power supply system "Smart Home".

The subject of the study is to determine the relationship between the energy supply system and the smart home system.

Methodological principles are based on modern methods of modeling and programming of microprocessors.

CONTENTS

INTRODUCTION

A system that provides resource savings and security for all users. It is assumed that this system is able to recognize and respond to specific situations occurring in the home. The system functions as a complex or a separate structure, according to the set tasks and availability conditions, combining important protective and comfort conditions.

Smart home is the direction of the future of any high-tech country, where all sectors of society will move to the convenience of residential, office, industrial and military structures of the state. But the main task will be a constant and uninterrupted power supply to all these structures. There are many of ways to support and provide all the necessities of a smart home. The main task of the future and the present will be full automation controlled by human control systems, logic module centers, and programs of artificial intelligence or its prototypical versions of today's response system programs.

With the development of progress it is possible to control smart homes through all available means of communication, these are computers, cell phones, control panels, tablets and other types of gadgets. Which means the full implementation into everyday life devices capable of working with a smart home, not only on its territory, but also outside of it. Human interaction with the living space gives a qualitatively new level of life, where the modes of all devices and systems are monitored and set in accordance with the internal and external conditions, through automation. The complex makes people's lives safe, comfortable within the living space and other structures of the society.

And all this needs to be provided with energy, which feeds these systems of different power sources, including alternative power sources, which will become quite everyday life. Such as solar panels, electric generators, wind turbine, human waste, and any other way that can contribute to powering smart homes.

Methodical work consists in studying the automated system of energy saving "smart home" and technologies for their implementation.

To solve the task, you can choose a number of tasks: the concept of "automated system of energy saving of a smart home with increased reliability" and the principle of its functioning; technologies of energy saving systems - "smart home".

Modeling and calculation of an automated system for energy saving of a smart home with increased reliability.

CHAPTER 1
OVERVIEW OF EXISTING SOLUTIONS

1.1. The concept of "smart home"

The concept of "smart home" was formulated by the Institute of Intelligent Building in Washington, DC in the 1970s: it is a building that provides productive and efficient use of workspace [1].

The principle of "Intelligent building management system" provides a completely new approach to the organization of life of the building, in which due to a set of software and hardware significantly increases the efficiency and reliability of all systems and actuators of the building.

A "smart home" should be understood as a system that must be able to recognize specific situations occurring in the building and respond accordingly: one of the systems can control the behavior of others by pre-designed algorithms. The main feature of the intelligent building is the integration of individual subsystems into a single managed complex. An important feature and property of the "Smart Home" distinguishes it from other ways of organizing living space is that it is the most progressive concept of human interaction with living space, when a person in one team sets the desired environment, and automation in accordance with external and internal conditions sets and monitors operating modes of all engineering systems and electrical appliances. In this case, you do not need to use multiple remotes when watching TV, dozens of switches in lighting control, individual units in the control of ventilation and heating systems, video surveillance and alarm systems, gates and more.

In a house equipped with a system "Smart Home" just one click on the wall key or remote control or touch panel and choose one of the scenarios and the house itself will adjust the operation of all systems according to your wishes, time of day, weather, outdoor lighting.

To ensure a comfortable condition inside the house [2]. just one press on a wall key or remote control or touch panel and choose one of the scenarios and the house itself will adjust the operation of all systems according to your wishes, time of day, weather, outdoor lighting. To ensure a comfortable condition inside the house [2]. just one click on the wall key or remote control or touch panel and choose one of the scenarios and the house itself will adjust the operation of all systems according to your wishes, time of day, weather, outdoor lighting. To ensure a comfortable condition inside the house [2].

1.2. The concept of "smart home"

The concept of "smart home" can be interpreted as a "smartly built house". This means that the building should be designed so that all services could be integrated with each other with minimal costs (in terms of finance, time and complexity), and their maintenance would be organized in an optimal way [2].

The concept of intelligent building includes the following provisions:

1. Creation of an integrated building management system - a system with the ability to ensure the integrated operation of all engineering systems of the building: lighting, heating, ventilation, air conditioning, water supply, access control and many others.
2. Absence of building maintenance personnel and transfer of control and decision-making functions to the subsystems of the integrated building management system. The "intelligence" of the building is laid in these subsystems - an algorithm of actions in response to changes in the parameters of the system sensors and other events such as emergency situations.
3. Implementation of the mechanism of immediate disconnection and transfer, if necessary, to the management of any subsystem of the intelligent building. At the same time, a person should be provided with convenient and equal access to control and display of all subsystems and parts of the "Smart Home".
4. Ensuring the correct operation of individual subsystems in case of failure of the overall control system or other parts of the system.
5. Minimization of maintenance costs and modernization of building systems,

which should be ensured by the application of common standards in the construction of subsystems, automatic configuration and detection of new devices and modules when they are added to the system.

6. Presence in the building of the laid communication environment for connection to it of devices and modules of systems. Along with this, the possibility of use as a communication medium in the control system different types of physical channels: low-current lines, power lines, radio channel.

1.3. Smart Home Features

Intelligent building has a lot of advantages. The control system allows owners to create as many complex and intelligent operating procedures as they like, because all executive systems can work in harmony and together. Hence the implementation of many resource-saving procedures:

•access control and security

•accounting and control of almost all parameters of systems and rapid response to their critical change, and the reaction is comprehensive and instantaneous

•remote control and management of the building, because all information and control communication channels in such a system are digital.

With one touch you can turn an empty apartment into a cozy guest house: lighting will be turned on, a comfortable microclimate will be installed, curtains will be lowered, the bathroom will be filled. Tired and want to relax at the TV screen or "home theater"? Touch the panel or remote control - and the blinds will close, the light will turn off smoothly, the screen will slide out and the projector will turn on. You can heat up dinner without getting up - only someone has to put it on the stove in advance. You can control the "home theater", as well as audio and video equipment with the help of touch panels.

Using special dimmers, you can not only change the brightness of the lamp when turned on, but also the time for which this brightness will be achieved.

The function of constant control of illumination, intended mainly for office premises, gives the chance to support the set illumination of a working surface irrespective of whether the sun shines or the sky is hidden by clouds.

Automatic inclusion of external lighting depending on time of day and presence of people not only will provide additional comfort, but also scares away uninvited guests.

Figure 1.1 Light control device

The system constantly measures the temperature individually in each room and maintains it at a given level, directly controlling the radiator valves or dampers of the air conditioner, and, if necessary, automatically turns on or off ventilation [5].

Every day helps to save money due to different modes of operation of the system: comfort mode, night mode, "no one in the house" mode. Modes change on schedule or on command. It is enough to set the temperature only once on the display of the touch panel in the room for each of the modes. The heating / air conditioning system will turn off automatically to save energy if the windows of the room are open for ventilation.

Figure 1.2 Temperature control device

In summer, the slats of the blinds automatically rotate at a certain angle and prevent excess sunlight from entering the room without reducing the light flux. Thus, they prevent heating premises and help to save the electric power spent by the conditioner.

Figure 1.3 Blinds control device

The smart home reports to the front about all the events that took place in it during the absence of the owners: who and when came, how long he was in the house, what suspicious people were spinning around him for a long time. Their faces and actions are recorded in his memory [7].

Uninvited guests are waiting for unpleasant surprises in the form of blinding light and sound siren. In addition, their penetration into the house will notify you by phone and call security.

In case of emergencies (for example, water leakage) will not only inform the relevant service, but also take the necessary measures to localize the accident (stop water supply).

During your absence, the house can mimic the usual lifestyle of the hosts, including lights and music in the evenings, thus creating the effect of presence.

1.4. Features of "smart home" projects

Individual design of cottages is a whole complex of works, starting from the direct construction of the building, ending with the creation of a system of "smart" housing. The project development process must meet the technical requirements of GOST 2.114-95, as well as the norms of a single system of design documentation in accordance with GOST 2.053-2006. In a complex for the design of country houses, equipped

"Smart features" include:

- development of lighting management system;
- creation of the concept of multimedia systems (home theaters, music centers);

- climate control installation;
- ventilation, air conditioning, heating and water supply management;
- installation of power electricity system;
- sewerage system integration;
- installation of security system, dispatching;
- connection of any systems at the request of the customer (system of landscape watering, system of anti-ice on a roof, steps, paths and drains). Individual designing cottages and installation systems security, in which need country houses – security and fire alarms, firefighting,access control, call the security service, etc. [10].

1.5. Economic aspects

In all countries with developed market economies, both taxpayers' incomes and expenditures are transparent, and the latter are virtually all citizens. Clear control of income and expenses allows such institutions as mortgage lending (issuance of loans for construction and purchase of housing) to work effectively. This leads to the fact that buying a home on credit can afford the majority of the working population. Everyone who took a loan to buy a home will "live in debt": the lion's share of his income will flow to repay the loan. Without risk insurance in this case, legal relationships are not possible in these economic processes.

Therefore, in many countries there is already a practice of compulsory home insurance. Naturally, insurance companies are interested in the quality and reliability of insured housing. But since the occurrence of insurance cases is inevitable, the insurance companies seek to then collect money from the real culprits, for example - construction companies [8].

The "intellectual building" is able to provide experts with the "black box" on the contents of which conclusions will be drawn. Therefore, their development and implementation in countries with developed market economies are now accelerating. Even in Ukraine, modern and expensive office and residential buildings are already designed taking into account the requirements of the concept of IZ, for their further implementation.

In addition, the future owners of such houses are interested in their intelligence, because it undoubtedly brings significant savings to its owner through accurate accounting and control over all building systems, as well as the rational use of resources such as electricity, water, heat.

Conclusion to the chapter:

This section discusses the concept, opportunities, economic aspects, as well as features of "smart home" projects.

Home automation systems are divided into:

- open;
- closed

Open systems are KNX, LonWorks, MODbus, BACnet. The advantages of open systems are a wide selection of equipment from different manufacturers, which is correctly integrated into the engineering complex of the building without adapters. The isadvantages of open systems are the high cost and complexity of setup.

Closed systems are Domintell, Clipsall, AMX, Crastron, Control-4. They are used in cases where it is enough to solve a local problem without further modernization and connection with automation from other manufacturers.

The disadvantages of the above solutions are their high cost and complexity in setting up, upgrading and expanding. Therefore, the creation of a management system

"Smart home" with the possibility of easy expansion and low cost is relevant.

CHAPTER 2
ANALYSIS OF SMART HOME MANAGEMENT SYSTEMS

2.1. The main functions of the "Smart Home" system

The "smart home" is a modernized house that contains a modern technologically organized system that improves people's lives. This system provides comfort, safety and resource saving for users, as it is able to respond to specific tasks and is able to recognize specific situations that occur in the house. One system can control another system. For example, when the temperature rises, the system can automatically close the windows in the house and turn on the air conditioner.

Currently, the concept of "Smart Home" is developing rapidly and has created another system - "Internet of Things".

2.2. Energy saving

"Smart homes" contain energy-saving systems that save 10-15 times the amount of electricity consumed. Lighting and heating control devices are used for this purpose. Energy-saving lighting is achieved by setting the time of on and off lamps. For this purpose the whole graphic schemes of control of lamps are developed. Also, the maximum savings can be obtained if you properly design the house so that as a result it is illuminated by natural light. A good idea, of course, is the use of energy-saving lamps, but if it burns in an empty room, it will be a meaningless source of energy. Indoor heating is also controlled by the system itself. Temperature sensors respond to the environment and accordingly give commands to the Central Committee, which in turn regulates the temperature in the house. This, of course, the best savings are provided by automatic light switches using infrared and electronic sensors.

Light sensors determine the level of light in the room and, depending on the indicators, give a signal to turn on or off the lights, or if a person entered the room using motion sensors. The energy saving system is also based on temperature sensors that determine the condition of the rooms [12].

Lighting management is one of the most important tasks in the house. Thanks to intelligent programming, you can save electricity and lamp life. There is no need to look for light switches in the dark, as well as turn off the light when leaving the room [12]. The intelligent system will turn off the light only after the host falls asleep and turn on the soft lights, if you wake up at night, so as not to irritate the eyes with bright light. And in the morning the system will decide what kind of lighting is needed in the house depending on the weather outside.

The automated lighting control system can be set up in such a way that it will determine in which part of the room a person is and illuminate it. In a country cottage, the system can include an evening under the light of the yard and decorative lighting of the facade of the building. It greets you or your car in the evening with the lights on in the yard and garage.

The "Smart Home" system contains algorithms for controlling the air environment and different climatic zones in the premises, while using a minimum of energy costs. Thanks to its help, the premises are heated or cooled. This system is responsible for simultaneously controlling the air conditioning network and heating networks. It is also responsible for lowering the temperature at night in rooms where there are no people, allows you to create comfortable sleeping conditions and thus save energy. The system is especially effective because it can minimize the operation of equipment and facilities in the absence of the owner in the house. Before returning home, you can program the climate control system for a comfortable indoor mode via phone or the Internet.

Indoor climate control system allows you to adjust the temperature, humidity, fresh air flow individually for each room, control the operation of the air filtration system, create an individual climate system for each family member, the weather in the house. At the same time, the climate control system, despite the large number of functions, saves money and solves the problem of energy saving. For example, the system can be set up in such a way that on weekends and non-working hours the heat supply to the room is reduced or turned off completely. This mode of operation is especially relevant for use in country cottages with the use of autonomous heating systems. This system allows you to remotely turn on the boiler or switch it to economy mode.

To ensure the adjustment of the parameters of the system, various sensors are used, which record the current indicators of the microclimate in the premises of the house. When using them, the system is able to control air quality (temperature, humidity, ozonation) according to the season and day, ventilation mode using automatic window opening system, change the mode of heating radiators and underfloor heating, automatically maintain temperature and humidity in special rooms.

2.3. Emergency control

A special place in the structure of a smart home is occupied by the emergency safety system. It ensures the safe operation of engineering systems in the house. As a result, the safety system will check the correct operation of gas supply and water supply systems and inform the user about all emergencies, both in the house and in the protected area.

Failure of elements of the water supply system is not as destructive as, for example, a fire, but it can lead to a domestic "catastrophe". To prevent the sad consequences of water flow, a smart home uses special sensors [13].

Leak sensors are installed in places where the probability of leakage is highest: most often under the bath or washing machine. In the event of moisture on the floor, the sensors will send a signal to the valves that shut off the water supply to the system, thus preventing flooding. At the same time, the smart home will send a conditional signal to your mobile phone, warning of an accident.

Similar actions will be taken by the security system in the event of a gas leak. If propane, methane, butane appear in the air, special sensors will react, there will be an emergency shutdown of the gas supply, exhaust ventilation will turn on automatically, and homeowners will be notified of the event by message or call to a mobile phone.

Thus, the security system of a smart home not only monitors the operation of all systems, but also responds to emergencies, while notifying the owners.

2.4. Existing communication technologies in Smart Home systems, X-10 technology

The most common technology today for the implementation of a "smart home" is the X-10. It appeared in the early 80's and became the first system that made it possible to implement an automated house. The software algorithm is created so efficiently that when you press one button, several commands are executed. Also for the operation of the system using motion sensors, light, humidity. Moreover, the system is very flexible because it integrates in a matter of hours. This system works from the usual wiring (220 V, 50 Hz), which transmits information signals. That's why X-10 is so common, because you do not need to lay new cables or destroy the apartment, because everything is already necessary.

X-10 technology is quite convenient and intelligent, because it can be programmed for any needs. X-10 does not contain a central controller: each device receives an individual address to which it will find a command sent from the remote control and this technology can be expanded. If the user wants to improve their system, this technology allows it because it is easy to integrate. It is easy to connect additional modules to the system, which means that your home is gradually "getting smarter". Among all the positive qualities of the system is the low cost. To date, this system is the cheapest. The principle of implementation is shown in Fig. 2.1 [14].

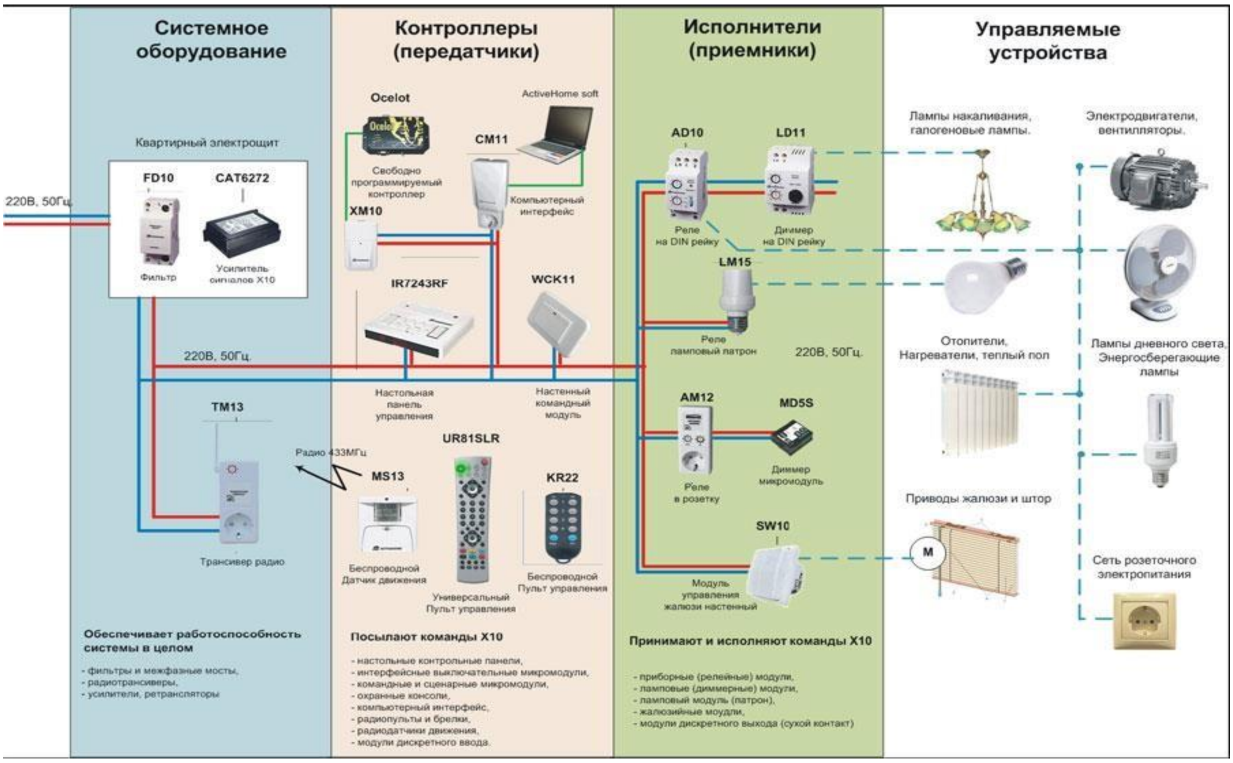


Figure 2.1. Example of implementation of X-10 technology

The disadvantages of the technology are also enough: the data rate on the wiring is quite low, in addition, there is a limit on the number of control groups [14].

2.5. C-Bus technology

One of the most common technologies for managing a "smart home". Each microcontroller of this system can be configured, and the whole network of such controllers can control the whole house. Each link has its own memory, which is not damaged in the event of a power failure. This makes the system quite reliable, so it is on this technology to build complex and secure systems. The principle of operation is shown in Fig. 2.2 [15].

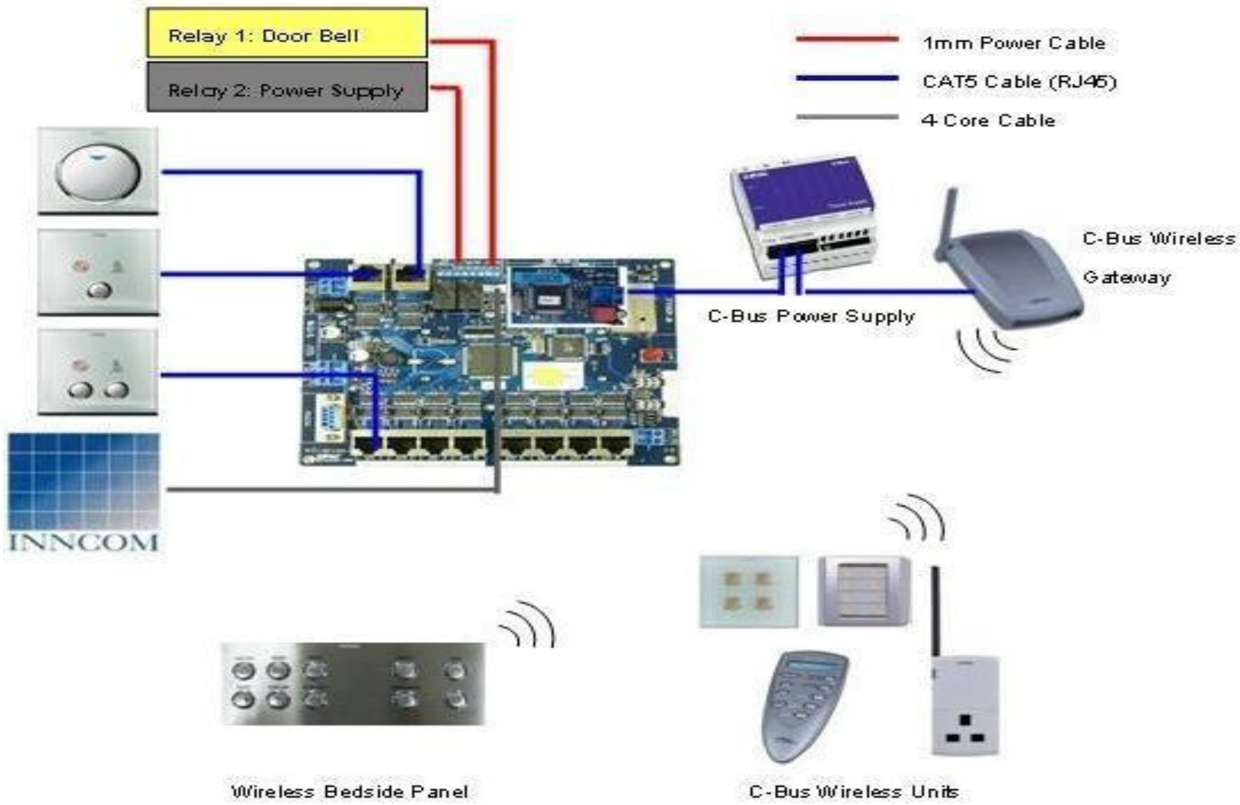


Figure 2.2. Example of C-Bus technology implementation

C-Bus - a system that allows you to control the house remotely without a server, because the controller with a permanent IP address connects to the Internet and to the "smart home" and data is transmitted via TCP / IP protocol. That is, you can control the system from a remote phone or computer. This technology allows you to combine up to 100 devices in one network and 255 networks in one system [15].

2.6. LonWorks technology

The systems, which are built on LonWorks technology, are similar in architecture to the EIB. However, thanks to the ability to program built-in controllers, you can implement more complex projects. Of course, the information is provided only when there are external changes in the premises, so the network is free of congestion. The principle of operation is shown in Fig. 2.4 [15].

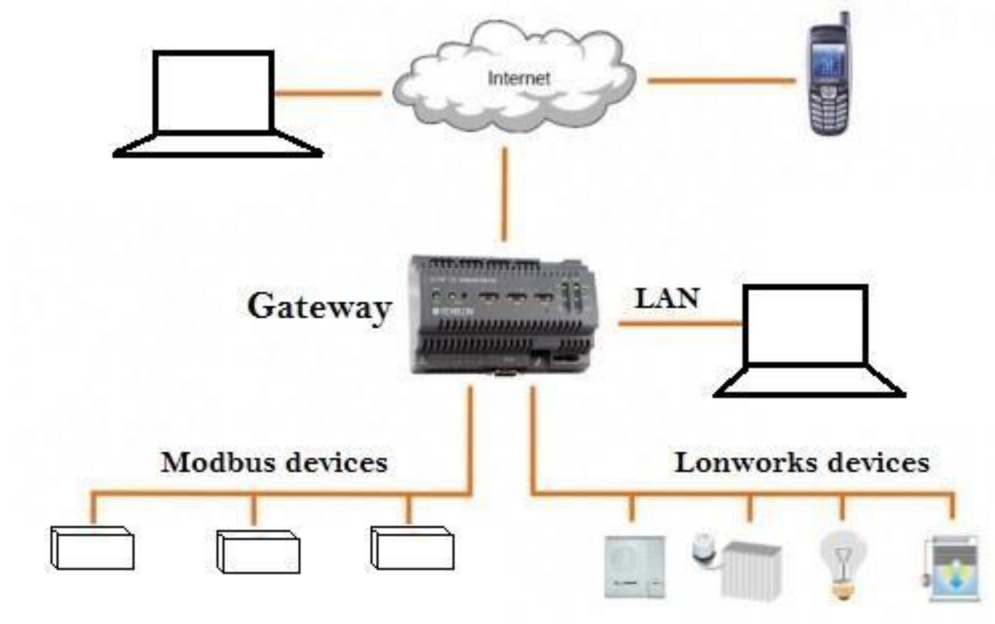


Figure 2.4. The principle of implementation of LonWorks technology

The control system is implemented thanks to the control network LON (Local Operating Network), which has a minimum number of levels of hierarchy. This system does not have a CC. LonWorks technology was created for the automated industry and transportation system. It is now used to build distributed systems with a large number of nodes spaced apart. This technology is most common in the United States [15].

2.7. Classification of "Smart Home" systems

After analyzing the principles of implementation of existing systems, we can offer the following classification according to the principle of connection between the individual modules of the system:

- Centralized system;
- Decentralized system;
- Mixed system;

The first group is a centralized system consisting of a host computer to which executive-command modules are connected. They interact through a central computer that provides control signals through a communication channel (bus). All settings are stored on the server, and the peripherals execute only the commands received from it. The architecture of such a system is shown in Fig. 2.6.

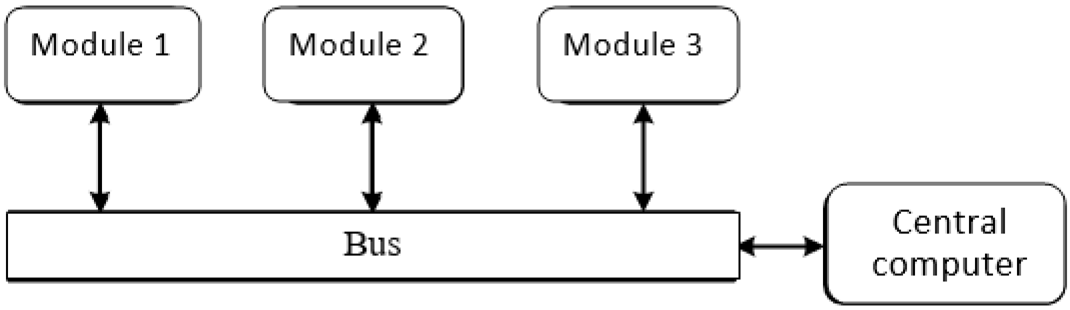


Figure 2.6. Architecture of the centralized system

This concept makes it possible to assemble an automated system with a single set of execution and connect devices from different manufacturers, despite the different communication channels that currently exist. The centralized system also has high functionality and a high-quality graphical interface. Unfortunately, there are downsides to this concept: high cost; large areas for technological equipment; the failure of the central controller leads to the failure of the entire system; system design requires high qualification and extensive experience; installation of the system occurs during the construction of the premises or its overhaul.

The second group is a decentralized system. As the name implies, the main control center in the system is missing. The system consists of modules that detect changes in the characteristics of the house and respond to these changes through a controller that is built into the module. Interaction algorithms are prescribed from the controller program directly to the memory of each device and to change them the device will need to be reprogrammed. Due to the lack of a central component, the connections between the devices are established directly and it is possible to create autonomous groups closed to each other. The architecture of this system is shown in Fig. 2.7.

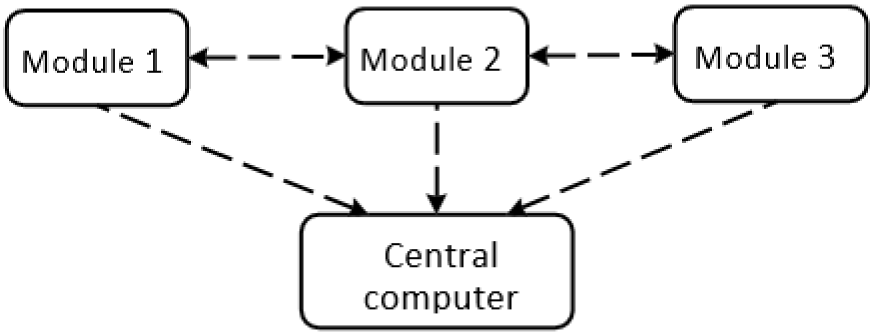


Figure 2.7. Architecture of the decentralized system

This concept does not depend on the central unit, so all functional modules can work autonomously. Accordingly, it increases the reliability of the system in operation. This technology has good prospects for expansion and modernization of equipment, as well as flexibility in programming to meet customer needs. The disadvantages of this architecture include: relatively high price; system design requires high qualification and extensive experience.

The third group is a system that includes decentralized and centralized systems, in order to increase management flexibility and compensate for the shortcomings that exist in both systems. The architecture of this system is shown in Fig. 2.8.

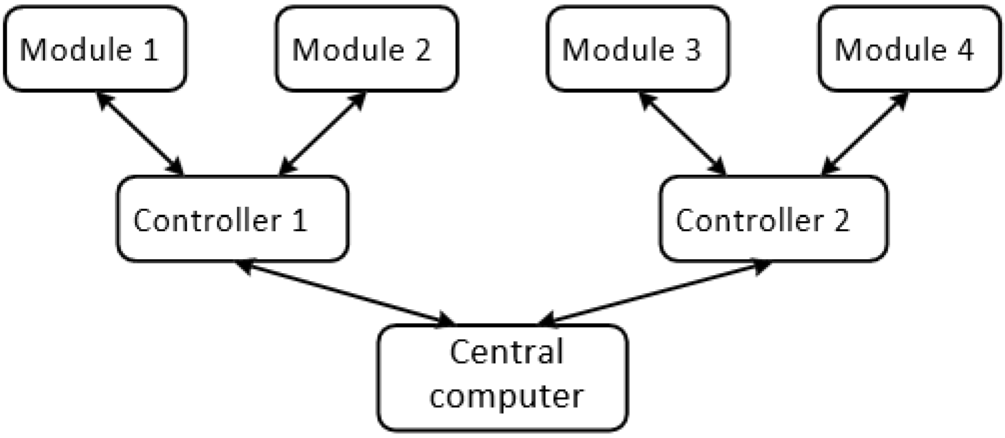


Fig. 2.8. Mixed system architecture

This concept is effective in terms of "smart home" management. Intelligence to solve the most complex problems is in the central computer (CC), which is responsible for the operation of the entire system, especially child microcontrollers (DM). The CC constantly exchanges information with the DM through communication channels, and they are already with these modules. What is interesting about this system is that if the CC fails, it will work, because DMs have their own control logic, ie their own algorithm, which is responsible for performing various functions. CC is used to ensure more complex operation of the system, for more flexible use. Without a CC, child controllers cannot exchange information for more efficient management of the entire system, but reliability during operation in this system is the highest. Of course, this concept is used in important military or scientific centers for high reliability of data protection and security of the building, as this system is expensive and requires a lot of resources to maintain, but this does not prevent everyone from having this control system for "smart homes".

Conclusion to the chapter:

Having considered the advantages and disadvantages of each of the above architectures, it was decided to implement a control system for a mixed architecture of the system "Smart Home".

CHAPTER 3
ANALYSIS OF THE CURRENT STATE AND DIRECTIONS OF DEVELOPMENT OF AUTONOMOUS POWER SUPPLY SYSTEMS

3.1. Ways implementation combined autonomous systems electricity supply with the participation of renewable energy sources

Currently, the world is undergoing significant changes in approaches to energy policy: the transition from an outdated model of the energy sector, which is dominated by large producers, fossil fuels, inefficient networks, imperfect competition in the markets of natural gas, electricity, coal - to a new a model in which a more competitive environment is created, opportunities for development are equalized and the dominance of one of the types of energy production or sources and ways of fuel supply is minimized. At the same time, preference is given to improving energy efficiency and energy use from alternative and renewable sources. This usually takes into account and implements measures to improve the reliability of energy systems, as well as, as a result, reduce harmful emissions into the atmosphere and adapt to climate change.

The organization of backup power supply is especially relevant in conditions of severe wear of general power grids. In many cases, a power outage for even a few hours can be costly. The quality of electricity produced by autonomous generators has parameters at the level and sometimes better than in a centralized network. This is especially important when using them as energy sources for facilities equipped with equipment that is sensitive to the quality of electricity.

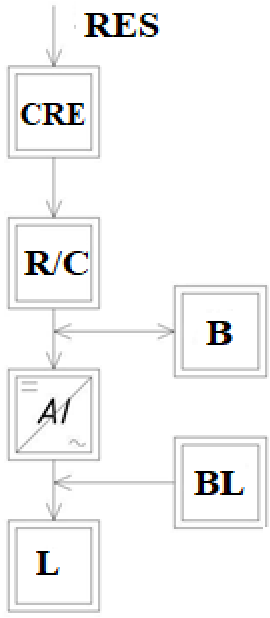
The degree of participation of renewable energy electrical equipment in the electrification of the facility depends on many factors, among which the most important are: the energy potential of RES and its change over time, the needs object in power and energy, requirements for reliability of power supply, economic indicators.

Depending on these and other factors, the composition and structure of the autonomous power supply system of the facility is selected.

In terms of composition, modern power plants for autonomous power supply can be built on the basis of autonomous wind and solar power plants or on the basis of joint use of renewable energy power plants and diesel power plants. The option with diesel generation can be implemented using DES as a backup power source, or to work with renewable energy installations on the total load [22].Variable nature schedules power consumption and energy potential of renewable energy sources, an autonomous power supply system needs to add to the main equipment a device for storing electricity. The generalized structure of autonomous solar and wind power plants is shown in Figure 3.1.

This circuit is powered by a rechargeable battery via a stand-alone inverter. The power of the inverter drive is selected for the peak load power. The average load power at a specific time interval is determined by the positive energy balance of the drive, when its energy received from RES exceeds the energy given to the load (taking into account efficiency and rational modes of operation of power equipment, especially batteries). Ballast load accepts possible excess electricity that is not consumed in the current time interval by the battery and load. [23].

At present, it is not possible to provide uninterrupted power supply to powerful consumers only through renewable energy sources: significant daily changes in wind potential and solar radiation, which usually do not correspond to seasonal changes in energy consumption schedules.



RES - renewable energy sources;

CPE - converter of primary energy resource;

R / C - Rectifier or converter of electricity;

B - Battery;

AI - autonomous inverter;

L - load;

BL - ballast load.

Figure 3.1 - Autonomous power supply using RES

The combination of a sustainable source of electricity (DES) and an unstable renewable allows you to build universal energy systems with high technical and economic characteristics that reliably provide power supply to various decentralized facilities [23].

The possibility of disconnecting the power plant during periods of high values of the potential of renewable energy resources is achieved by complicating the composition of the hybrid energy complex and control algorithms for its elements.

A generalized scheme of a hybrid power supply system of this type is shown in Fig.3.2.

During the period of high potential of RES, the diesel generator is switched off. Fluctuations in electricity consumption and generation from RES are smoothed by the energy reserve in the UPS batteries, which reduces the number of power plant starts.

In the mode of separate operation, the PPE of the renewable energy source must have a relatively large installed capacity. Accordingly, the instantaneous power of a wind or solar power plant can significantly exceed the rated load. The use of BN ballast load is envisaged for utilization of excess electricity.

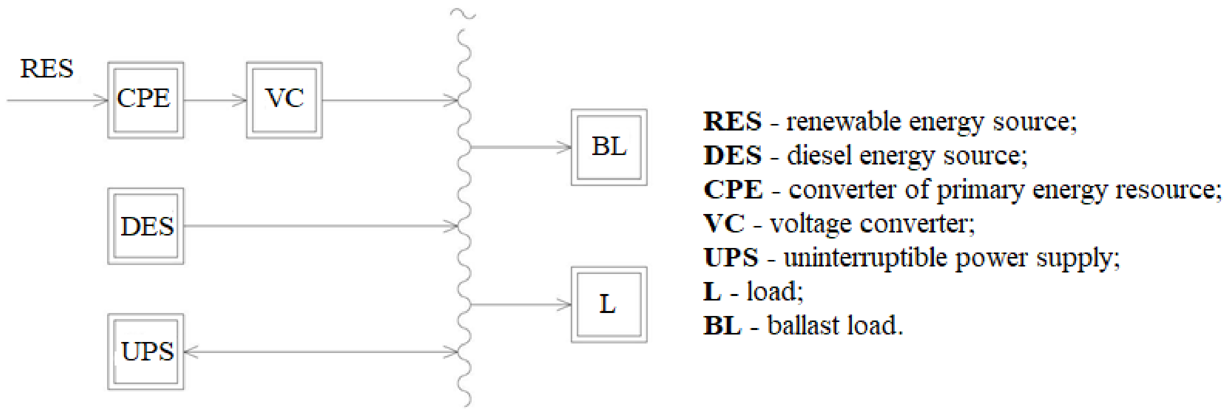


Figure 3.2 - Hybrid energy complex with duplicate DES.

The share of "green" electricity in the overall energy balance of this power supply system is usually at least 50%.

At lower installed capacities of renewable energy plants, the load on diesel generation increases. The increase in the relative duration of the modes of generation of the converter of the primary energy resource, RES is insufficient for the current coverage of the load, determines the feasibility of modes of parallel operation of the fuel and renewable component of the hybrid power supply system. Implementation of this mode requires additional complication of control algorithms of the energy complex by the introduction of appropriate equipment: a universal inverter capable of operating autonomously and in parallel with the mains, a synchronization device [18].

The structure of such complexes is shown in Fig.3.3.

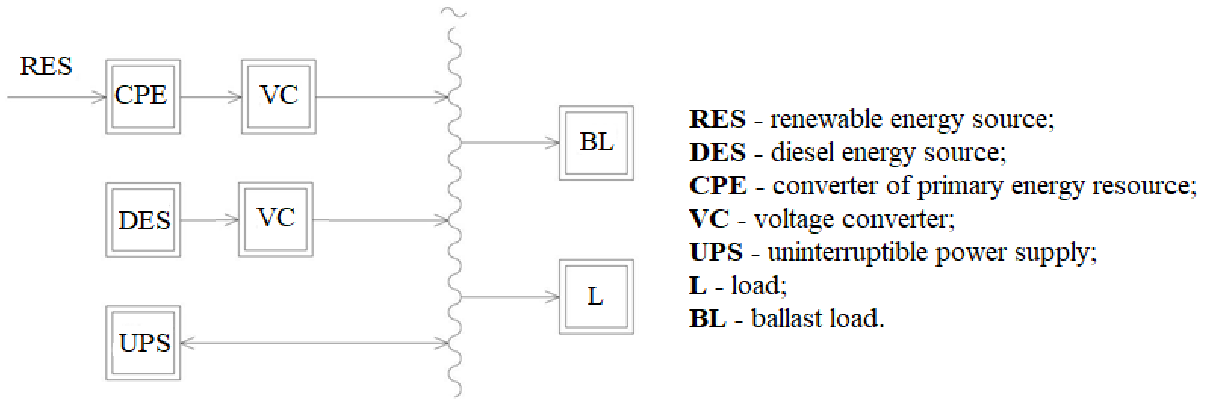
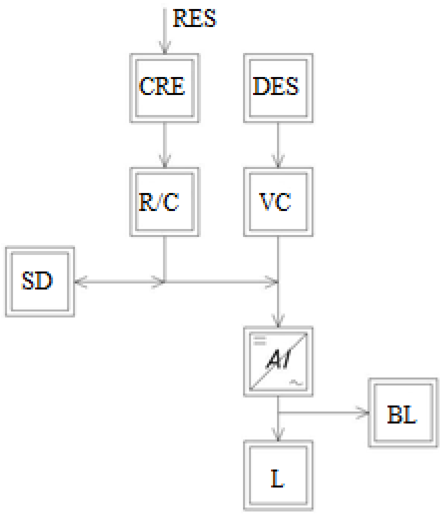


Figure 3.3 - Hybrid power complex with AC bus and inverter DES



RES - Renewable energy source;
DES - diesel power plant;
CPE - converter of primary energy resource;
L- load;
BL - ballast load;
R / C - rectifier or converter of electricity;
VC - voltage rectifier;
SD - storage device;
AI - autonomous inverter.

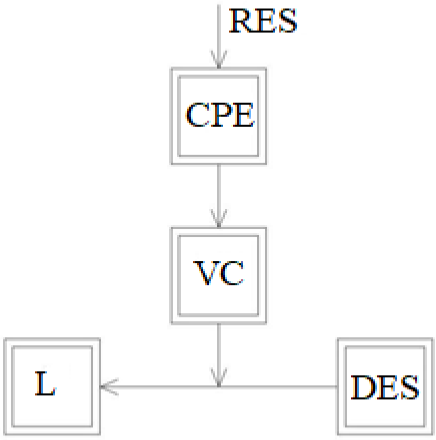
Figure 3.4 - Hybrid power complex with DC bus.

Typically, as a voltage converter (hereinafter - PN) in such systems are used rectifier-inverter frequency converters. The same converters are part of modern wind farms. This fact, as well as the generation of electricity by photovoltaic DC modules, determine the possibility of combining the power sources of the hybrid system on the DC bus (Fig. 3.4).

The advantages of using AC bus are manifested in the construction of a distributed generation system, which usually occurs when integrating RES power plants into existing power supply systems [19].

Joint work in the autonomous power supply system of power plants and renewable energy installations is most rationally described as the operation of wind and photovoltaic power plants on the electrical network formed by the diesel power plant. DES in this case is considered as the main source of electricity, and participation in the generation of renewable energy sources can save a significant part of fuel [20].

The conditions of stability and reliability of the power supply system are determined by the power ratios of DES and network inverters photo or wind power plants, such that the instantaneous power does not exceed 40-50% of the capacity of the power plant. The structure of such a complex is shown in Fig.3.5.



RES - renewable energy source;
CPE - converter of primary energy resource;
DES - diesel energy source;
VC - voltage converter;
L - load.

Figure 3.5 - Hybrid energy complex with a permanent DES

The advantage of such complexes is their simplicity, which allows you to reduce initial investment and reduce part service equipment.

Small amount of diesel generation replacement is the main drawback similar systems.

3.2. Global trends and threats to the development of renewable energy sources energy

Currently, the dominant position in the electricity generation market is occupied by centralized energy, consisting of large power plants and an extensive network of transmission lines (transmission lines).

The peculiarity of centralized energy is the concentration mainly near such energy resources as coal, fuel oil, oil, powerful rivers, etc. However, often large consumers of electricity are located far from energy sources, which implies the presence of transmission lines of different lengths. Transportation of electricity over long distances entails its inevitable losses.

Ukraine is a typical example of a country with an already developed system of centralized electricity supply and at the same time has a significant need for decentralized energy sources.

Separate networks have a number of undeniable advantages, such as:

- low losses due to the small distance of consumers from the source;

- unloading of existing lines with all the ensuing advantages;

- increasing the reliability of electricity supply by increasing the number of sources.

The most widespread decentralized power supply systems are to provide electricity to the following groups of consumers:

- individual consumers of small power from units to tens of kW - cottages and country houses, meteorological stations, cellular communication towers, field objects and expeditions, farms, frontier, radar and navigation posts, etc .;

- group non-industrial consumers with an installed capacity of tens to hundreds of kW - individual large residential buildings and neighborhoods, various objects of the social sphere, trade enterprises and health care institutions, villages, hamlets, settlements of low-rise buildings, etc .;

- industrial enterprises with an installed capacity of hundreds to thousands of kW.

It should be noted that the generally accepted term "small energy" does not currently exist. In the power industry, small power plants include power plants with a capacity of up to 30 MW with units with a unit capacity of up to 10 MW.

One of the most promising areas for improving the energy efficiency of local power supply systems is the use of renewable energy sources in the energy balance of the regions and the optimization of the modes of operation of basic energy equipment.

In the general case, decentralized power supply systems based on RES, depending on the type of use of primary energy can be divided into groups:

- wind power plants;

- photovoltaic modules;

- small hydroelectric power plants;

- geothermal stations;

- thermal power plants (cogeneration and trigeneration systems), biomass energy and / or fossil fuels are used as primary fuel.

Governments of different countries (Germany, USA, Sweden, Norway, Denmark) pay great attention to improving energy efficiency and investment attractiveness of projects with renewable energy sources, which allowed to bring alternative energy to the forefront, demonstrating its undeniable advantages in the generation of electricity.

The state of RES in developing countries is due to the need to electrify autonomous consumers. These countries often have favorable climatic conditions for the introduction of RES-based power plants (China, African countries, Latin America, etc.).

Last year, 44% of all new capacity in wind energy fell on Germany (5443 MW), followed by France (1561 MW).

In France, the Netherlands, Finland, Ireland and Lithuania, record-breaking wind power capacity has been set.

In Denmark, the share of wind in electricity consumption was 36.8%, in Ireland - 27%, in Portugal - 24.7%, in Spain - 19%, in Germany - 16%.

Thus, it can be emphasized once again that the share of wind power plants and renewable energy sources in general in the production of electricity in the EU is growing. [24]

According to the Law of Ukraine "On Alternative Energy Sources", alternative energy sources - renewable energy sources, which include solar energy, wind, geothermal energy, energy of waves and tides, hydropower, biomass energy, gas from organic waste, gas from sewage treatment plants, biogas, and secondary energy resources, which include blast furnace and coke oven gases, methane gas, degassing of coal deposits, conversion of waste energy potential of technological processes [21].

Imbalance in the development of the energy complex focused on centralized electricity and heat supply and significant (over 40%) energy production at nuclear power plants; requirements to reduce greenhouse gas emissions, increasing the cost of primary energy, shortages and gradual depletion of fuel and energy resources, leads to the need to use energy from alternative sources in the economy. The use of alternative energy sources has become especially relevant in the spread of the concept of its sustainable development [22]. The concept of sustainable development was first proposed in 1987 in a report of the United Nations Commission on Environment and Development. The main goals of the concept are formulated in international documents and programs developed under the auspices of the UN, and relate to a wide range of issues covering economic, social and environmental areas of activity [23].

In the conditions of Ukraine with the help of wind turbines it is possible to use 15 -

19% of the annual volume of wind energy that passes through the cross section of the wind turbine surface. The average annual amount of solar radiation per 1 m2 of surface in Ukraine ranges from 1070 kW * h / m2.

Ukraine annually receives 720 billion MWh. solar energy, equal to 88,400 million tons. n. This is much higher than the current energy consumption of our country.

At present, the share of RES in the structure of energy generation in Ukraine is 0.075% (Fig. 1.14). Ukraine's energy strategy until 2035 envisages a 25% increase in RES use. The greatest development is expected in the use of wind and solar energy [24].

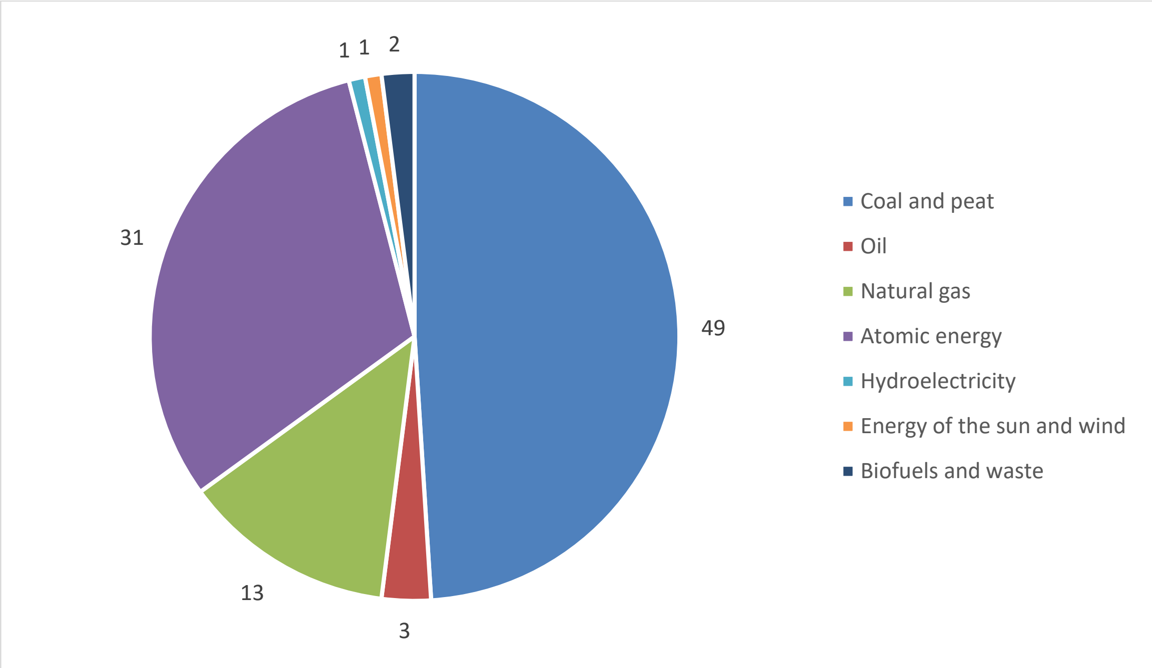


Figure 1.14. The structure of primary energy consumption in Ukraine in 2019

In 2015, an updated Energy Strategy of Ukraine until 2035 was adopted [24], which takes into account current trends in global energy development. The priority areas of the Energy Strategy are the following:

Stimulating the construction of SES and WPPs, promoting the creation of a system for forecasting electricity generation;

- commissioning of new HPP and PSP units (subject to confirmation of environmental safety of projects;
- increasing the use of biomass in the generation of electricity and heat;
- stimulating the generation of electricity by low-capacity RES institutions;

- ensuring the implementation of projects to decentralize energy supply at the local level (based on the use of renewable energy, "smart grids", improving energy efficiency);
- creating conditions for the formation of a system of logistics and infrastructure for the collection of biological raw materials and its further transportation;
- study of the possibility and, if appropriate, the introduction of the use of batteries to balance the energy system, including in order to eliminate the uneven operation of generating capacity of RES;
- improving the mechanism of stimulating the production of power equipment in Ukraine.

According to this document, the forecast of technically achievable use of RES potential in 2030 will be 12.6% of the total installed capacity or 8 GW (14 GW including hydropower), and the generation volume - 14 TW*h (28 TWh including HPP) [24].

The use of alternative sources, both worldwide and in Ukraine, has a number of obvious advantages over traditional resources:

- the use of RES allows to reduce the level of emissions into the atmosphere and environmental pollution, reduce the cost of recycling waste energy facilities;
- renewable sources are inexhaustible;
- payback periods for the construction of energy facilities using RES are shorter than for fossil fuel power plants;
- the cost of energy supply to decentralized consumers and regions is less;
- the use of RES is associated with the development of knowledge-intensive industries with a multiplicative economic effect;
- RES is closer to the consumer, which reduces transportation costs.

However, along with the above advantages of using RES, there are a number of tasks that significantly slow down the process.

For the effective development of RES, normative legal acts are needed that stimulate the use of RES and ensure in practice free access of their producers to electric networks.

Energy produced using alternative sources has a high cost, high investment risks and initial capital costs, which makes such a project less attractive and profitable for investors. In addition, the daily, seasonal and weather instability of electricity generation from RES, less capacity of heating and power plants, insufficient development of mechanical engineering and technological base for the production of equipment, unpreparedness of the fleet for the mass transition to biofuels, the tendency of electricity networks to centralized supply and large unit capacity [25].

3.3. Opportunities and barriers on way using potential alternative energy sources

Global energy development trends Decarbonization of energy is gaining more impact in terms of preventing climate change, which affects the formation of the balance of energy generating capacity. The adoption of the Paris Climate Agreement poses a challenge to the international community to set new goals for combating climate change and intensifying efforts, including in Ukraine.

An important role in this task will be played by nuclear energy, hydropower, wind energy and other RES that emit the lowest amount of greenhouse gas emissions. The solution to the problem of decarbonization of the energy sector will be facilitated, in particular, by Ukraine's unchanging position on the expediency of using nuclear energy.

Ukraine considers nuclear energy as one of the most cost-effective low-carbon energy sources. Further development of the nuclear energy sector for the period up to 2035 is projected based on the fact that the share of nuclear generation in total electricity production will increase.

Revolutionary technological innovations are expected in the field of transport. Ahead - in the coming decades - is expected to progressively abandon the internal combustion engines of hydrocarbons and replace a significant part of such vehicles with rolling stock that will use zero-emission electric motors and environmentally friendly hydrogen engines.

Thus, growing competition in world energy markets and rapid scientific and technological progress in the development of RES and alternative fuels expand Ukraine's choice of sources and routes of primary energy resources, optimize the energy mix and, in the long run, reduce greenhouse gas emissions.

It is envisaged to constantly expand the use of all types of renewable energy, which will become one of the tools to ensure the energy security of the state. In the short and medium term (by 2025), the NES forecasts an increase in the share of renewable energy to 12% of ZPPE and at least 25% - by 2035 (including all hydropower and thermal energy). Wind and solar energy. With further reduction in the price of RES, their economically justified potential will increase.

At the same time, the expansion of the use of renewable energy directly by the consumer does not fall under the limitations of the energy system and forms the prospect of dynamic development at the local level. Public policy should be focused on stimulating the initial initiative of private market players. The development of decentralized renewable energy (for example, photovoltaic systems and solar collectors on the roofs of residential buildings, etc.), the potential of which is estimated at ~ 5% of electricity consumption by the population, should also be encouraged.

The share of the electricity sector, which uses solid biomass and biogas as an energy resource, will grow, due to both the relative sustainability of production (if there is a resource base) and the tendency to form local generating capacity. Preference will be given to the simultaneous production of heat and electricity in cogeneration plants and the replacement of hydrocarbon fuels. Hydropower. Hydropower plays an important role in the sustainability of the UES of Ukraine, as it provides the energy system with highly maneuverable capacity in regulating daily load schedules with peak coverage and filling night gaps, as well as serves as an emergency power reserve. Until 2025 it is necessary to complete the reconstruction of existing HPP capacities and construction of new HPP and PSP units, which will allow to keep the most economical and maneuverable ones in the generation structure, as well as to increase their capacity. The main measures for the implementation of strategic goals in the RES sector:

- conducting a stable and predictable policy to stimulate the construction of SES and WPPs;
- conducting international communication campaigns to encourage international strategic and financial investors to enter the RES market of Ukraine;
- construction and commissioning of 5 GW of RES capacity (except for high-capacity HPPs);

- increasing the use of biomass in the generation of electricity and heat by: o stimulating the use of biomass as a fuel in enterprises, where biomass is a residual product; o informing about the possibilities of using biomass as a fuel in individual heat supply; o promoting the creation of competitive biomass markets. Management system
- Exclusion of political influence on the activities of state-owned companies,
- full implementation of leading corporate governance standards (eg OECD principles);
- distribution of functions and powers of government to regulate each from energy markets in accordance with the requirements of the Third Energy Package;
- introduction of modern practices of corporate governance of state energy companies;
- introduction at the level of business entities of the practice of analysis and response to threats to the operation of energy facilities (contingency planning);
- decentralization of power, transfer of resources and responsibility for the functioning of housing and communal services and communal energy to the local level;
- promoting the decentralization of energy supply systems, the use of local fuels and renewable energy sources;
- ensuring the opening for consumers of the structure of tariffs for natural gas, electricity, heat, their transportation. [strategy]

International experience in the use and development of alternative energy shows the need to support projects using RES by state and regional authorities and dictates effective methods of energy supply, which provides the following benefits [26]:

Consider barriers that prevent the realization of the existing technical potential of alternative energy projects. Such obstacles can be divided into the following groups:

- legislative;
- economic;
- scientific and technical;
- information;
- psychological.

Legislative barriers to the use of RES are the lack of a single legislation in the field of alternative energy, only a number of legislation related to low energy, the implementation of the Kyoto Protocol. In addition, there are no approved state goals and priorities for the development of RES. There are also no regulations that would ensure in practice free access of independent producers to the electricity grid. The barrier is the insufficient development of existing mechanisms to stimulate the development of RES (tax benefits, subsidies, compensations, liabilities, soft loans, etc.). Promotion of traditional fuel and nuclear energy; when comparing traditional and alternative energy sources, the ecological component of energy cost, the cost of utilization and processing of energy production waste is not taken into account [26].

State intervention in the formation of energy prices and the monopolistic structure of the energy market are the main economic

barriers to Ukraine's transition to RES. State control of energy prices and, as a result, setting below market prices, which often do not reflect the medium and long-term costs of energy production, is a significant barrier to attracting investment in modernization and capacity building of alternative energy [27]. Also, the obstacles are the low solvency of the population and enterprises and the lack of incentives to invest in this type of generation.

The scientific and technical barrier to the development of RES potential is manifested in the absence, for some types of energy, ready-made solutions for power supply systems, low level of standardization and certification of equipment, insufficient scientific and technical and technological developments and low level of knowledge about innovative technologies in this field [28].

Another barrier to the use of new fuels is psychological. The information barrier is the low awareness of the population, leaders and the public about the possibilities of RES. Lack of widespread propaganda on radio, television and in the press about the possibilities and benefits of RES, lack of information about positive examples of use [26].

Problems of energy supply with the use of alternative energy sources have been repeatedly studied in the scientific literature [27, 28]. Some authors consider the introduction of alternative energy technologies from a technical and technological point of view, others study the economic component of the energy supply process.

In [29] it is argued that given the great potential in the field of RES, for efficient use of energy from alternative sources in Ukraine requires compliance with a number of key tasks that will contribute to the creation of effective mechanisms for project implementation, namely regulatory, economic, methodological, information, personnel and organizational field of support. At the same time, the complexity of the development of projects using RES is the lack of scientifically sound recommendations and systematic approaches to the process of choosing the structure of energy supply in the regions.

In this regard, the issue of improving the methodological support for the development and implementation of alternative energy projects, as well as the task of assessing the risks of using RES at thermal power plants is a priority and very promising for Ukraine.

No less important issue related to the energy supply of regions using the potential of RES is the reduction of damage to the environment in the process of energy generation, which has a complex nature: pollution of water, air, soil. Obviously, one of the cardinal ways to solve the environmental problems of the energy sector is to reduce the use of traditional resources and the transition to RES.

Prospects for further research include the development of new and improvement of existing models of energy supply structure selection, methods of selection of priority energy generation technologies, planning of energy supply structure of regions using RES is possible provided

Conclusion to the chapter:

Today, the use of solar and wind energy have become the main types of renewable energy sources. According to existing estimates, the economic potential of RES has very great prospects for development and implementation in Ukraine. The main obstacle is dependence on existing economic conditions; cost, availability and quality of mineral and energy resources; regional features, etc. Renewable energy can make a significant contribution to solving the problems of increasing the reliability of electricity supply to consumers and will contribute to the decentralization of the UES system of Ukraine.

The most promising option for the construction of combined autonomous power supply systems is the implementation of projects for a combination of centralized power supply together with wind and photovoltaic generating units.

CHAPTER 4
DEVELOPMENT OF A AUTOMATED SYSTEM OF AUTONOMOUS POWER SUPPLY OF A SMART HOME OF HIGH RELIABILITY

4.1. Initial data

To develop this building system, we will use the initial data given in Table 4.1.

Table 4.1. - Initial data

Name	P, kW
Electric gas boiler Zhit-3 KS-G-0 / 16SN / KE-4.5	0.07-4.6
Pump station Metabo HWW 40/4500	1.3
Ventilation system	0.3
Air conditioning system	1.5
Refrigerator and household electrical appliances	0.04-0.3
Lighting	0.3
Irrigation system	0.8
Other consumers	1.5
Control and execution systems "Smart House"	0.5
Total:	9.9

4.2. Choice of cable lines

4.2.1. Selecting the supply line

We select the cross-section of the cable or wire for the long-term permissible current. The rated current in the cable or wire must be less than the continuous permissible current, taking into account the correction factors. The calculated current is determined by the formula:

$$I_P = \frac{P_P}{\sqrt{3} \cdot U_H \cdot cos\varphi} \quad (4.1)$$

where Pp - design power, kW; UH- rated voltage, kV; cos φ- power factor = (0.5).

Check the selected cross-section for the economic current density by the formula:

$$F = \frac{I_P}{J_{ec}}, \quad (4.2)$$

Where Jec is the economic current density (1.7), A / mm².

We check the selected section for voltage losses, if the losses exceed the permissible ones, then the section must be increased:

$$\Delta U = (Pp \cdot L)/(C \cdot F \cdot \cos \varphi), \quad (4.3)$$

where Pp is the rated power, kW; L - line length, m; C is the coefficient taken 72 - for copper, 44 - for aluminum at a line voltage of 380V of a three-phase line with zero, and 12 - for copper and 7.4 for aluminum at a phase voltage of 220V of a two-wire line ; F - conductor cross-section, mm²; cos φ - power factor. The calculations are summarized in Table 4.2.

Table 4.2 - Calculation of the cross-section of the supply line.

Ip, (A)	F, (Amm²)	ΔU, (V)
28	5470	0.92

Based on the design parameters for laying the overhead line, a wire of the SIP-5 type, 4x6 mm², made of aluminum alloy was chosen.

The choice of power wires for electrical appliances.

For a three-phase network, calculations are made according to the formula:

$$I = P/(\sqrt{3} \cdot U \cdot cos\varphi) \,, \quad (4.4)$$

where P is the rated power, kW; U- rated voltage, kV; cosφ- power factor = (0.5).

For a single-phase network, calculations are made according to the formula:

$$I = (P \cdot K)/U, \quad (4.5)$$

where I is the current strength, A; K-coefficient of simultaneity; P - power, W; U- voltage, V.

Table 4.3 - Cross-section of wires for consumers

Consumer name	Consumption P, kW	Cross section mm²	I, (A)	P, kW
Electric gas boiler Zhit-3 KS-	4.6	4x1.5	16	10.5
G-0 / 2SN / KE-4.5	1.3	3x1.5	19	4.1
Pump station Metabo HWW 40/4500	0.3	3x1.5	19	4.1
Ventilation system	1.5	3x1.5	19	4.1
Daikin FBQ air conditioning system	0.04-0.3	3x1.5	19	4.1
35C8 / RXS35L	0.3	3x1.5	19	4.1
Refrigerator and household	0.8	3x1.5	19	4.1
electrical appliances	1.5	3x1.5	19	4.1
Lighting	0.5	3x1.5	19	4.1

4.3. Calculation of protection devices

For short-circuit protection in this work we use QF circuit breakers.
The selection of circuit breakers is made according to the same four conditions as the selection of fuses.
The rated current of the thermal release of the machine will be determined

$$I\text{т. р} \geq Imax\ , \qquad (4.6)$$

where Iт.р - rated current or insertion of a thermal release of a circuit breaker with an unregulated or adjustable inversely dependent on current characteristic (regardless of the presence or absence of cutoff), A; Imax- maximum rated load current, A.

For electric motors, the circuit breaker must be selected according to the conditions

$$I\text{т. р} \geq\ 1{,}25Inom, \qquad (4.7)$$

$$I\text{у. э. о.} \geq\ 1{,}25\ Istart, \qquad (4.8)$$

where Inom is the rated current of the electrical receiver, A; Istart - starting current of the electric receiver, A; Ie.e. - nominal value of the current of the insert of the instantaneous electromagnetic release (cut-off), A. 1.25 is a coefficient that takes into account the spread of characteristics when setting up automatic machines, as well as inaccuracy in determining the starting current.

For a group of electrical consumers:

$$I\text{т.р} \geq 1{,}1\ Imax., \tag{4.9}$$

$$I\text{у.э.о.} \geq 1{,}2\ (I'start + I'max), \tag{4.10}$$

where Istart is the highest starting current of one electrical consumer in this group, A.

When a group of electric motors is started simultaneously, the total starting current of this group.

I'max is the rated maximum current of the remaining power consumers of the group operating in continuous mode, A.

The circuit breaker must reliably disconnect any type of short circuit in networks with a solidly grounded neutral.

The electrical installation rules of clause 1.7.79 require that the short-circuit current exceed at least three times the rated current of an unregulated release or the current insertion of a circuit breaker with an inverse current-dependent characteristic.

When protecting networks with automatic switches that have only an electromagnetic release (cut-off), the short-circuit current multiplicity relative to the insert should be taken at least 1.4 with rated currents up to 100 A, and not less than 1.25 with rated current more than 100 A.

Long admissible wire current is selected according to the condition

$$Idop \geq I\text{р}, \tag{4.11}$$

$$Idop \geq (\text{К}prot \cdot Iprot)/\text{К}p, \tag{4.12}$$

Under normal laying conditions, Kp = 1.

Selectivity should be ensured between the series-connected switches in the 0.4 kV network, between the high-voltage protection of the 6 (10) / 0.4 supply transformer and the 0.4 kV switches, as well as the switch and the magnetic starter of the protected line.

Selectivity between series-connected circuit breakers with only a thermal release can be ensured provided

$$I\text{a.r.b} \approx 1{,}5\, I\text{a.r.m}, \tag{4.13}$$

where Ia.rb is the starting current of the thermal release of the overlying protection stage, A; Ia.rm is the starting current of the thermal release of the lower protection stage, A. When protection is performed by automatic circuit breakers with combined or electromagnetic releases, selectivity cannot be ensured in all cases where the short-circuit current in the line protected by the smaller circuit breaker may be greater than the current insert instantaneous trip (cut-off current) of the larger switch. This is due to the fact that the time of their disconnection from short-circuit currents is approximately the same, despite the difference in rated currents.

Table 4.4 - Selection of protective devices

No. auto off QF	i nom. (A)	It.r (A)	I number of author off (A)
1.3	26.05	31.9	32
2	12.1	15.3	16
4	3	6.1	ten

4.4. Calculation of short-circuit currents

A short circuit is any short circuit between phases that is not provided for by normal operating conditions, and in networks with a grounded neutral also short circuits of one or more phases to ground or a neutral wire.

In networks with isolated neutral, a short circuit of one of the phases to earth is not a short circuit. However, a simultaneous earth fault of two or three phases is a short circuit.

In grounded neutral systems, there are three-phase, two-phase and single-phase short circuits. In systems with isolated neutral - three-phase, two-phase and two-phase to earth. Various combinations and combinations of the above types of short circuits are possible. In addition to short circuits at one point, short circuits can be observed simultaneously at various points in the network.

The causes of short circuits are damage to the insulation and incorrect actions of the maintenance personnel.

In the event of a short circuit, the total resistance of the electrical system decreases sharply. This leads to an increase in the currents flowing in individual elements of the electrical installation, as well as to a decrease in voltage, especially near the accident site.

An increase in currents causes heating of live parts, and also leads to mechanical damage to elements of electrical installations. Reducing the voltage negatively affects the work of consumers, and can also lead to a violation of the stable operation of the system.

Short-circuit currents are calculated to solve the following main tasks:

- selection of a wiring diagram, its assessment and comparison with others;
- identifying the conditions of work of consumers in emergency modes;
- choice apparatus electrical installations and checks conductors by the conditions of their work in case of short circuits;
- design of protective grounding;
- design and configuration of relay protection;
- analysis of accidents in electrical installations.

Short-circuit currents are calculated using one of two methods, named units method or relative units method.

The procedure for calculating short-circuit currents

Payment currents short closures underway in following sequence:

1. Choose a design scheme. For the calculation, a basic electrical circuit of primary switching is used. The part of the system is taken where it is necessary to determine the short-circuit current. The diagram is made in a single-line design. It includes generators, power lines and other elements that connect power supplies to a short circuit point. Each element of the circuit is assigned its own serial number, and its nominal data are indicated.

The design mode of the system is determined, which ensures the maximum or minimum short-circuit currents, the design point is selected (on the substation buses, at the end of the line, etc.) and the design type of short circuit (three-phase, two-phase, single-phase), as well as the design time of the transient process ($t = 0$; $t = 2.5$ s, etc.). To check the substation high-voltage devices for thermal and dynamic stability, it is necessary to know the maximum value of the short-circuit current. In this case, design conditions are considered: all power sources are on; a short circuit occurred at the installation site of the devices; the type of short circuit is such that the current will have the greatest value; the short-circuit time is assumed $t = 0$. To assess the sensitivity of relay protection, the design conditions should be such

2. Make up the equivalent circuit. To do this, all elements of the design scheme are replaced with electrical resistances, and the EMF value is indicated for power sources.

The resistances of electrical devices (switches, disconnectors, etc.), as well as connecting cables and switchgear buses are not taken into account, since their values are small.

3. They transform the equivalent circuit to the simplest form. Using the rules known from electrical engineering, the resistances of the equivalent circuit are converted to one resultant, on one side of which there is a power source, on the other, a short circuit point.

4. Select the type of short circuit. It is determined by the calculation problem. If you need to know the maximum values of the currents, then in networks 10 and 35 kV these are three-phase short-circuit currents, minimum two-phase. In networks with a solidly grounded neutral voltage of 110 kV and above, as well as 380/220 V, single-phase short-circuit currents can be higher than three-phase.

The short-circuit current is determined directly. Different calculation methods can be used depending on the calculation tasks and the design model.

4.5. Calculation of grounding devices

The main conditions, which necessary stick to at the construction of grounding devices are the dimensions of grounding electrodes.

Depending on the material used (angle, strip, round steel), the minimum dimensions of ground electrodes must be at least:

a) strip 12x4 - 48 mm2;

b) corner 4x4 cm;

c) round steel - 10mm2;

d) steel pipe (wall thickness) - 3.5 mm.

Minimum dimensions fittings, applied for mounting grounding devices Figure 4.2.

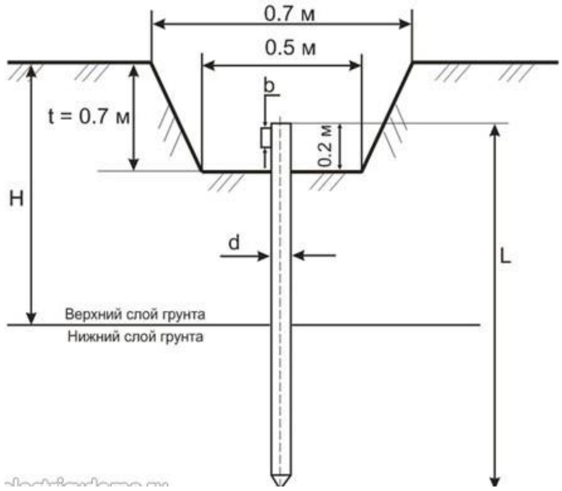


Figure 4.2- Ground rod

The length of the grounding rod must be at least 1.5 - 2 m.

The distance between the grounding rods is taken from the ratio of their length, that is: a = 1xL; a = 2xL; a = 3xL.

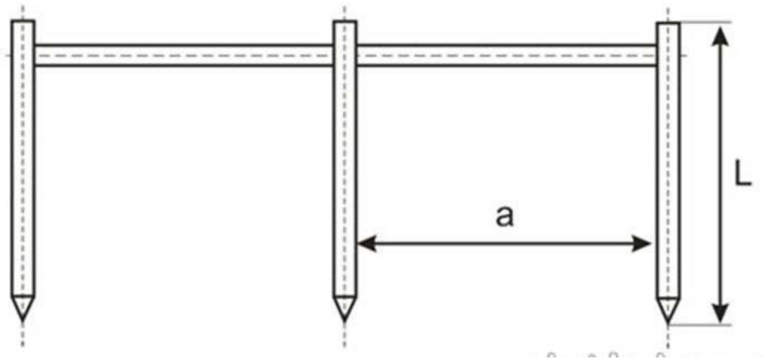


Figure 4.3. Distance between rods

Depending on the allowable area and ease of installation, grounding rods can be placed in a row or in the form of a figure (triangle, square, etc.).

The purpose of calculating protective grounding

The main purpose of calculating grounding is to determine the number of grounding rods and the length of the strip that connects them.

Example of calculating grounding

Resistance to current spreading of one vertical ground electrode (rod):

$$R_0 = \frac{\rho_{экв}}{2\pi * L} * \left(\ln\left(\frac{2L}{d}\right) + 0.5\ln\left(\frac{4T+L}{4T-L}\right)\right), \quad (15)$$

Where ρ_{eq} - equivalent soil resistivity, Ohm m; L- rod length, m; d - its diameter, m; T- distance from the ground surface to the middle of the rod, m.

In the case of installing a grounding device in a heterogeneous soil (two-layer), the equivalent soil resistivity is found by the formula:

$$\rho_{экв} = \frac{\psi * \rho_1 * \rho_2 * L}{\left(\rho_1(L-H+t_r) + \rho_2(H-t_r)\right)}, \quad (16)$$

Where ψ - seasonal climatic coefficient;

ρ_{one}, ρ_2-specific resistance upper and bottom layer soil respectively, Ohm m (table 5); H- thickness of the upper soil layer, m; t - deepening of the vertical ground electrode (trench depth) t = 0.7 m.

Since the resistivity of the soil depends on its moisture content, for the stability of the resistance of the ground electrode and to reduce the influence of climatic conditions on it, the ground electrode is placed at a depth of at least 0.7 m.

Table 4.5. - Specific soil resistance

Priming	Soil resistivity, Ohm m
Peat	20
Soil (black soil, etc.)	50
Clay	60
Sandy loam	150
Sand with groundwater up to 5 m	500
Sand with groundwater deeper than 5 m	1000

The deepening of a horizontal ground electrode can be found by the formula:

$$T = \left(\frac{L}{2}\right) + t\,. \quad (17)$$

Installation and installation of grounding must be done in such a way that the ground rod penetrates the upper soil layer completely and partially the lower one.

Table 4.6 - The value of the climatic coefficient of soil resistance

A type grounding electrodes	Climatic zone			
	I	II	III	IV
Rod (vertical)	1.8 ÷ 2	1.5 ÷ 1.8	1.4 ÷ 1.6	1.2 ÷ 1.4
Stripe (horizontal)	4.5 ÷ 7	3.5 ÷ 4.5	2 ÷ 2.5	1.5
Climatic signs of zones				
Average perennial lowest temperature (January) to C	from -20 + 15	from -14 + 10	from -10 to 0	from 0 to +5
Average perennial highest temperature (July) C	from +16 to +18	from +18 to +22	from +22 to +24	from +24 to +26

Number rods grounding without accounting horizontal grounding resistance is formula:

$$n_0 = \frac{R_0 * \psi}{R_H}, \tag{18}$$

where the Rн-normalized current spreading resistance the grounding device is determined based on the rules of PTEEP (Table 4.7).

Table 4.7 - The highest permissible value of the resistance of grounding devices (PTEEP)

Electrical installation characteristics	Soil resistivity ρ, Ohm m	Grounding device resistance, Ohm
An artificial earthing switch to which the neutrals of generators and transformers are connected, as well as repeated earthing switches of the neutral wire (including in the room inputs) in networks with a grounded neutral for voltage, V:		
660/380	up to 100	15
	over 100	0.5 ρ
380/220	up to 100	thirty
	over 100	0.3 ρ

220/127	up to 100	60
	over 100	0.6 ρ

As you can see from the table, the normalized resistance for our case should be no more than 30 ohms. Therefore, Rn is taken equal to Rn = 30 ohms.

Resistance to current spreading for horizontal earthing:

$$R_r = 0.366\left(\frac{\rho_{экв} * \psi}{L_r * \eta_r}\right) * \lg\left(\frac{2 * L_r^2}{b * t}\right), \tag{19}$$

Where Lr,b- length and width of the ground electrode; ψ - coefficient of seasonality of the horizontal ground electrode; η_r is the coefficient of demand for horizontal ground electrodes.

We will find the length of the most horizontal ground electrode based on the number of ground electrodes:

$Lr = a * (n_0 - 1)$ - in a row; $= a$ - along the contour.

a- the distance between the grounding rods.

Let us determine the resistance of the vertical ground electrode taking into account the resistance to current spreading of the horizontal ground electrodes:

$$R_в = \frac{R_r * R_H}{(R_r - R_H)}. \tag{20}$$

Complete quantity vertical ground electrodes determined by formula:

$$n = \frac{R_0}{R_в * \eta_в}, \tag{21}$$

Where $\eta_в$ - the coefficient of demand for vertical ground electrodes (table 8).

Table 8 - Coefficient of used ground electrodes

For horizontal earthing		For vertical earthing	
Number of	Along the contour	Number of	Along the contour

electrodes	Distance ratio between electrodes to their length a / L			electrodes	Distance ratio between electrodes to their length a / L		
1	2	3	4	5	6	7	8
4	0.45	0.55	0.65	4	0.69	0.78	0.85
5	0,4	0.48	0.64	6	0.62	0.73	0.8
8	0.36	0.43	0.6	10	0.55	0.69	0.76
10	0.34	0,4	0.56	20	0.47	0.64	0.71
20	0.27	0.32	0.45	40	0.41	0.58	0.67
30	0.24	0.3	0.41	60	0.39	0.55	0.65
50	0.21	0.28	0.37	100	0.36	0.52	0.62
70	0.2	0.26	0.35	-	-	-	-
Number of electrodes	In a row The ratio of the distance between the electrodes to their length a / L			Number of electrodes	In a row The ratio of the distance between the electrodes to their length a / L		
4	0.77	0.89	0.92	2	0.86	0.91	0.94
5	0.74	0.86	0.9	3	0.78	0.87	0.91
8	0.67	0.79	0.85	5	0.7	0.81	0.87
10	0.62	0.75	0.82	ten	0.59	0.75	0.81
20	0.42	0.56	0.68	15	0.54	0.71	0.78
30	0.31	0.46	0.58	twenty	0.49	0.68	0.77
50	0.21	0.36	0.49	-	-	-	-
65	0.2	0.34	0.47	-	-	-	-

The utilization factor shows how the spreading currents from single ground electrodes affect each other with different locations of the latter. When connected in parallel, the spreading currents of single ground electrodes mutually influence each other, therefore, the closer the grounding rods are to each other, the greater the total resistance of the grounding loop.

The number of ground electrodes obtained in the calculation is rounded to the nearest larger one.

In our work, we accept 4 vertical ground electrodes for installation, the total length of the horizontal ground electrode is 70 m with an average distance between vertical ground electrodes of 5 m. The length of the vertical ground electrode is 3 meters.

4.6 Heating

This work uses liquid heating at home. On the 1st and 2nd floor heating is carried out by floor heating, which will save heating costs. With this type of heating, the temperature of the coolant fluctuates at around 30 degrees. Savings range from 30-40%, in contrast to radiator heating, and more comfortable conditions are achieved.

To calculate the boiler power, use the formula:

$$MK = S * UMK / 10, \tag{4.22}$$

Where *MK*- rated power of the boiler in kW; S is the total area of the room in m2; UMK is the specific power of the boiler, which should fall on every 10 m2.

The latter indicator is set depending on the climatic zone and is:

- 0.7-0.9 kW for southern regions;
- 1.0-1.2 kW for the middle band;
- 1.2-1.5 kW for the Sumy region;
- 1.5-2.0 for the northern regions.

The main indicator in this formula is the predicted heat loss of the structure. To find out their value, you need to use another formula:

$$Qt = V * Pt * k / 860, \tag{4.23}$$

where V is the volume of the room, m3; Pt is the difference between external and internal temperatures, ° C; k is the dissipation factor, which depends on the thermal insulation of the building. The dissipation factor varies depending on the type of building.

For buildings without thermal insulation, which are simple structures of wood or corrugated iron, the dissipation factor is 3.0-4.0.

For structures with low thermal insulation, typical for buildings with single brickwork with ordinary windows and a roof, the dissipation factor is taken to be 2.0-2.9.

For houses with an average level of thermal insulation, for example, buildings with double brickwork, a standard roof and a small number of windows, a dissipation factor of 1.0-1.9 is taken.

For buildings with increased thermal insulation, well-insulated floors, roofs, walls and windows with double-glazed windows, a dispersion coefficient in the range of 0.6-0.9 is used.

Based on the specified conditions for heating a living area of 140 m2.

A boiler with a capacity of 16 kW is suitable; to ensure the greatest efficiency, a heating boiler operating on gas and electricity was chosen. Heating power from gas is 16 kW, heating power from electric heaters is 4.5 kW. In this development, due to the use of modern technologies of building insulation, the maximum efficiency of thermal energy is achieved, and in combination with the use of heating in the floor covering, maximum resource savings are achieved.

Calculations of the amount of pipe will depend on the loop pitch and the pipe laying method. The main methods of laying are "snake" and "snail". In our case, it will be more rational to use the "snail" method (Figure 4.4).

Pipe laying options: simple, corner or double loops (snakes), spirals (snails). For narrow corridors and rooms of irregular shape, snake laying is used. Large areas are divided into sectors. Combined laying is allowed: in the edge zone, the pipe is laid out with a snake, in the main part - with a snail.

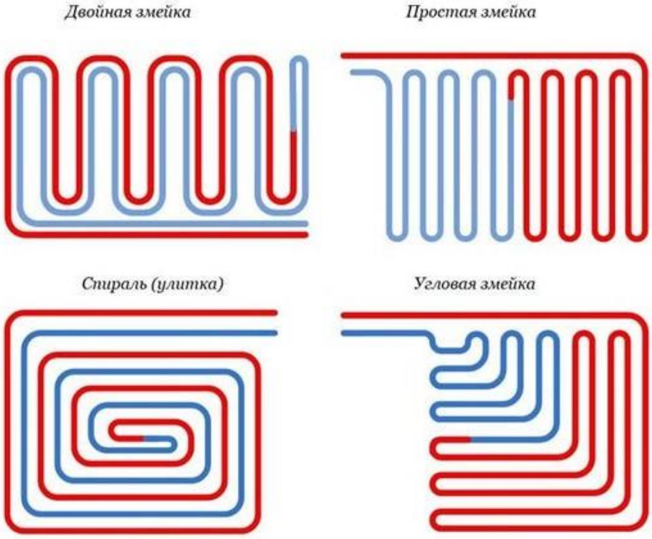


Figure 4 - Options for laying pipes for a water-heated floor

Around the perimeter, closer to the outer wall and near the window openings, the contour feed passes. The installation spacing in the edge zones may be less than the distance between pipes in the central part of the room. Connecting the reinforcements of the edge zone is necessary to increase the power of the heat flow.

Heat Q (W), which produces 1 square meter of low-pressure water circuit, is the total flux of radiant (≈ 4.9 W / m²) and convective (≈ 6.1 W / m²) energy:

Qtpmax hour = (αl (tpola-tok) + αk · (tpa-air))

$$, W\ [\alpha l \times (tfloor\text{-}tok) + \alpha k \times (tfloor\text{-}tair)] \times S,\ (W), \quad (4.24)$$

where αl and αk are radiant and convective energy fluxes, W / m²;

t floor- flooring temperature, ° C;

current- temperature of walls and ceiling, ° C; tair - room temperature, ° C; S- useful area of the contour, m².

The calculation of underfloor heating determines the heat consumption of a residential building in accordance with regulatory documents on thermal protection of buildings and construction heat engineering:

$$Q = (\alpha l + \alpha k) \times S \times (tfloor - tair),\ (W), \quad (4.25)$$

$$tfloor = Q / [(\alpha l + \alpha k) \times S] + tair,\ (°\ C), \quad (4.26)$$

$$\text{at } S = 1m^2,\ tfloor = Q / (\alpha l + \alpha k) + tair,\ (°\ C). \quad (4.27)$$

When the room temperature is heated by 1 degree, heat from the floor surface is transferred to the air:

$$\Delta t = tfloor - tair = 1\ °\ C, \quad (4.28)$$

$$Q = (\alpha l + \alpha k) \times S \times \Delta t = (4.9 + 6.1) \times 1 \times 1 = 11\ (W). \quad (4.29)$$

Floor temperatures (internal air temperature + maximum permissible superheat temperature) are assumed according to the following values:

- residential and office premises, the main heating surface is 29 ° C;
- edge zones 35 ° C;
- bathrooms, indoor pools, 29 ° C;
- short-term used premises 35 ° C;
- workplaces with permanent footwork 27 ° C.

The estimated length of pipes for a warm floor is determined by the formula:

$$L = (S / a \times 1.1) + 2c, (m), \tag{4.30}$$

Where L- contour length, m; S- area, contour, m²; a- laying step, m; 1.1- an increase in the size of the bending step (margin); $2c$- the length of the supply pipes from the collector to the circuit, m.

The laying step for our work is 200mm, pipe costs per 1 running meter = 5 meters. Pipe diameter for this type of pitch = 20mm.

The total area of underfloor heating on 2 floors is 142 m2, which means that based on the formulas, we need about 710-750 meters.

Main parameter calculation – performance pump in low-pressure circuit:

$$H = (P \times L + \Sigma K) / 1000, (m), \tag{4.31}$$

Where H- head of the circulation pump, m;

P- hydraulic loss per running meter of length (passport data from the manufacturer), pascal / meter;

L- maximum length of pipes in the circuit, m;

K- power reserve factor for local resistance.

$$K = K1 + K2 + K3, \tag{4.32}$$

Where $K1$- resistance on adapters and tees, connections (1,2);

$K2$- resistance on valves (1,2);

$K3$- resistance at the mixing unit in the heating system (1.3). The degree of performance possessed by the circulation pump

determined by the formula:

$$G = Q / (1.16 \times \Delta t), (m^3 / hour), \tag{4.33}$$

Where Q- heat load of the heating circuit (W);

1.16- specific heat capacity of water (Wh / kgC);

Δt- heat removal in the system (for low-pressure circuits 5 ÷ 10 ° C).

Based on the specified parameters of the heating circuit, a WiloStratos 25 / 1-4 circulation pump with a capacity of 12 cubic meters per hour is suitable for us. Rated power consumption of the pump is 300 W.

Selecting controls for this job

Output device and system control

We use the Busch-priOn module as the user interface. With the help of this device we are able to control all the functions of our “smart home” system. This device has a block-modular system that will allow you to achieve the most convenient use. This device uses a 3.5 TFT display to display information, control is carried out using a rotary knob, you can also add a 1,2,3 key sensor. The device is connected via the DHL bus.

Control device

To process signals and control devices, the Iridium server module is installed, which will allow us to control systems not only using the head unit, but also using mobile devices based on Android, Ios or Windows platforms. Simple programming will allow the user to independently change the parameters of the systems. With the help of the Iridiummobile program, a mobile device through a Wi-fi network controls and monitors all systems, as well as displays information about temperature, humidity and other information received from sensors. Programming in JavaScript and loading existing databases will allow you to quickly and accurately configure and adjust the system. This device has a function for monitoring the status of devices and systems, errors, accidents, and failures will immediately be displayed on output devices,

Power module

To control the power unit in our work, we used the HDL-MR 16.16 relay module. manufactured by Smartbus. This relay is installed on a DIN rail voltage 110-220 V, 50-60 Hz. The number of channels is 16, the load current is 16A, the maximum load current is 20A. This relay also has the ability to program, which will allow you to more accurately perform tasks. This relay acts as a circuit breaker, which in the event of a short circuit will disconnect the load on this line. The control is carried out via the communication bus with the control device, which disconnects consumer groups if the user does not use them.

This module has 16 channels and relays used in our work to power groups of electrical consumers. Each channel can be programmed according to a separate scenario, as well as use a turn-on delay of up to 25 seconds. This device also has a function of detecting the presence of a current, which will allow the device to be turned off when the leakage current is more than 30 mA, i.e. work in RCD mode.

Lighting module

Light control is carried out using the SB-DN-D0602 dimmer from Smartbus. This dimmer is DIN rail mounted and has 6 channels of 8 A per channel. Built-in scenario controller, overheat, overload, short circuit protection. The dimmer will automatically control the illumination of the premises, depending on the level of illumination received from the sensor. In the daytime, the light sensor will notify the control device that there is a sufficient level of light in the room, then the control device will turn off the power supply to the lighting of this room, thereby saving resources. Each channel on this device can be programmed in both automatic and manual modes. Each channel can receive up to 12 scenarios up to 1 hour in duration.

Control of curtains (blinds)

The curtains are controlled using the SW12 module and a servo drive. For more rational use of natural light, as well as for the performance of the presence module. This module can be controlled manually, remotely or programmed by a control device.

Heating and air conditioning control

Heating boiler and climate control is performed based on the readings of the climatic temperature, humidity and illumination sensor SB-CMS-THL. This is a multifunctional sensor that allows you to record several readings at once:

- humidity;
- temperature;
- illumination.

The sensor is also used as a firefighter due to the presence of installed sensors in it, and the presence of discrete inputs allows you to connect sensors for breaking, opening windows and doors.

In this way, one sensor can be used to perform several system functions.

The boiler is controlled by a modular relay, the heating valves are controlled by the WSU electric ball actuator, which receives a signal from the DIN-AO08 control module. This control will allow you to create the optimal temperature set by the user, as well as optimally use the heat energy. Possibility of connecting 8 ports for controlling drives or other climate control devices. Setting via the front panel or using the control. An input for emergency leak sensors will allow you to stop the fluid supply in the event of an emergency. Also, a connected pressure sensor will allow you to monitor the pressure in the heating system.

Safety

In this work, there are safety systems, such as protection against leakage of heating systems. Due to the placement of leakage sensors, the automation turns off the supply of fluid to the system when a signal from the sensor about a leak occurs. Since our heating system is under pressure, a pressure sensor is installed in the heating system circuit, which will allow you to notify about a decrease in pressure in the system. Gas and flame sensors are also installed around the perimeter, when these sensors are triggered, the system automatically turns off the supply of electricity, heating and water supply to the house, and transmits an alarm signal via SMS notification.

The effect of presence performed by the device with the logic controller SB-DN-Logic960 will preserve the effect of the presence of people in an empty house. Turning on and off lights in rooms, turning on street lighting, opening curtains, listening to music, all this will create the impression that people are really present in the house. In this controller there are 240 modules of 4 logical operations, a timer and a calendar will allow you to create scenarios that differ from each other over a long period.

For communication of devices and system elements, not only wired, but also wireless communication channels are used, such as WI-FI, due to the use of the Mikrotik Router BOARD 2011UiAS-2HnD-IN router in the system, which acts as an access point of the WI-FI network.

Since the initial concept was aimed at remote control of home systems, a GSM HDL-MGSM.431 wireless module was connected to the system. This module uses a GSM communication channel which is available almost throughout the territory of Ukraine. The module is connected directly to the system bus. The module can send SMS on 24 different events in the system, as well as perform actions on 99 SMS sent by the user, which will allow the user to control the systems at home, as well as receive notifications about accidents and outages from anywhere in the world. It is possible to program to call emergency services in case of fires or intrusion of strangers.

Irrigation system

On the territory adjacent to the house there is a greenhouse and a vegetable garden, in which elements of the smart home system are installed. The greenhouse has a soil moisture sensor, a temperature sensor that will allow the system to automatically open the ventilation window and turn on watering. To save money and ease of use, we collect these elements on the basis of the ArduinoUNO controller, the YL-69 soil moisture sensor, the DTH 11 humidity and temperature sensor and the ESP8266 WI-FI module. To water the garden, we use the same assembly on the Arduino only without the DTH 11 sensor.

The control of the TV, as well as other devices with the type of control by means of an infrared signal, is carried out using an HDLM / IRAC.1 infrared emitter with 4 transmission channels and 650 memory codes, which will allow you to control equipment using remote control panels based on an infrared signal.

The block diagram of the arrangement of devices is shown in Appendix B.

4.7. Analysis of automatic reserve input systems

In the thesis the task is to analyze and select the unit of automatic input of the reserve to ensure the reliability of the smart home.

Automatic backup input devices (ABP) should be provided to restore power supply to consumers by automatically connecting a backup power supply when the working power supply is disconnected, which leads to de-energization of consumer electrical installations [30, 31].

In our case, the ABP device must provide a continuous process.

A high degree of reliability of power supply to consumers is provided by power supply circuits simultaneously from two or more sources, because the emergency shutdown of one of them does not lead to loss of voltage at the outputs of power receivers [31].

Despite these obvious advantages of multilateral power supply, a large number of substations with two or more power sources operate on a unilateral power supply scheme.

The own needs sections of power plants also have unilateral power supply. The use of such a less reliable but simpler power supply scheme in many cases is appropriate to reduce the values of short-circuit currents, reduce power losses in step-down transformers, simplify relay protection, create the necessary voltage regime, power flows [30, 31, 32].

With the development of the electrical network, one-way power supply is often the only possible, as previously installed equipment and relay protection do not allow parallel operation of power supplies [31].

There are two main schemes of one-way power supply to consumers in the presence of two or more sources.

in the first scheme, one source is turned on and feeds consumers, and the second is disconnected and is in reserve.

The disadvantage of one-way power supply is that an emergency shutdown of the working source leads to the interruption of electricity supply to consumers. This disadvantage can be eliminated by quickly automatically turning on the backup source or turning on the switch on which the network is distributed. To perform this operation, special devices of automatic activation of the reserve (ABP) are used.

Operational experience shows that ABP is a very effective way to increase the reliability of electricity supply. the success rate of ABP is 90-95%. Simplicity of schemes and high efficiency have led to the widespread use of ABP in power plants and electrical networks.

All RIA schemes must meet the following basic requirements [30, 31, 32]:

The ABP device must be designed in such a way that it is possible to act when the voltage on the busbars of consumers for any reason, when disconnecting the relay protection of a damaged working source, in case of accidental or erroneous disconnection of the working power supply, .

Operational experience has shown that short circuits on busbars in many cases selfeliminate after de-energization and are not restored during subsequent voltage supply [32].

in these cases, the action of ABP is successful. In substations with two transformers operating on separate low-voltage busbars, combined devices APV and ABP are often used, providing [30, 31]:

at short circuit on buses or lines of consumers - APV switches off the switch of the transformer, ABP in this case is forbidden;

in the event of a short circuit in the working power supply, loss of voltage on it, its erroneous or involuntary disconnection - ABP backup source.

2. The duration of the power outage under the action of ABP is determined by two conditions [31]:

the need to ensure the deionization of the environment at the site of damage under the action of ABP in the event of a short circuit on the tires;

the need to ensure minimal violations in the technological process of consumers.

Restoration of tire insulation after disabling unstable damage is not instantaneous, but only after some time required for deionization of the environment in which the electric arc burned.

If the voltage is applied before the end of the deionization process, then the place of damage may re-ignite the arc, which means that the action of ABP will not be successful.

The deionization time of the medium depends on the voltage, as well as the magnitude and duration of the short-circuit current [31].

The assessment of the deionization environment in case of tire damage should be carried out taking into account the fact that synchronous and asynchronous electric motors of consumers can maintain voltage at the place of damage for some time after disconnection of transformers and thus support arc combustion.

From the point of view of ensuring the minimum losses in the technological process of consumers, it is desirable to set the time of ABP to a minimum. In most cases, the technological process is restored if the self-starting of electric motors is provided to consumers [29, 30].

By self-starting we mean the return of electric motors to the normal speed of rotation of the rotor when the voltage is restored after its short-term disappearance or complete disappearance as a result of a power outage.

As the duration of the power outage increases, the electric motors may stop completely, which will lead to a violation of the production process.

To prevent the violation of production technology and accelerate the self-starting of electric motors, the time of ABP should be the minimum possible.

The ABP device must provide a single action, which is necessary to prevent multiple switching on the backup power supply in the event of a stable short circuit. Repeated short-circuiting is dangerous for switching on the circuit-breaker, as this can lead to serious damage, and in some cases to its explosion and burnout of a large section of the busbar. In addition, this is unacceptable due to the possibility of disruption of the normal operation of consumers who are powered by a backup power source.

Activation of the backup source from ABP should be carried out only after disconnection of the switch of a working element from the party of tires of the consumer for shutdown of supply of pressure on the damaged element.

Therefore, usually the start of the ABP is performed from the auxiliary contacts in the drive of the switch.

In order to ensure the operation of the ABP in cases where the voltage on the busbars of the consumer is lost and the switch of the working power supply remains on, the ABP must be supplemented by minimum voltage protection, which controls the voltage on the busbars and acts to turn off the working power switch.

The presence of such protection is necessary for such schemes of primary connections, when the voltage from the reserved area can be removed by disconnecting the switches at other substations. the minimum voltage protection actuator, which monitors the presence of voltage on the busbars, shall not be actuated in the event of a blowdown of one of the fuses of the voltage transformers.

When performing ABP devices, it is necessary to check the conditions of overload of the backup power supply and self-starting of electric motors.

The protection of the circuit-breaker through which the voltage is supplied from the backup source must have a minimum operating time with such time as to limit the extent of equipment damage and the duration of voltage drop to the backup power supply when switched on for a long short circuit.

If the ABP is performed on a sectional or bus switch, the action of protection of this switch should be accelerated at operative inclusion and operation of ABP to zero for time of 0,5-1,5s. so that when switched on for permanent damage, the switch is switched off and not the operating power supply used for redundancy. After successful switching on of the switch the accelerated protection is deduced automatically and on the section or bus switch the protection which is selective with protections of lines remains.

On all switches on which the ABP device operates, it is necessary to control up serviceability of a circuit of inclusion of the switch of a reserve power supply.

In addition to the above basic requirements for ABP devices, in some specific cases, additional requirements may be imposed, in connection with which the locking elements are installed to ensure the proper functioning of automation. In this case it is necessary to consider that any complication of the scheme of automatic equipment and installation of additional relays reduce reliability of the device as a whole.

4.8. Selection of the scheme of automatic switching on of a reserve

The smart house is supplied by two working lines. In addition, there is a backup power line, which is turned on when any of the operating lines fails. The scheme of automatic activation of the reserve is shown on the sheet of the graphic part of the project.

ABP devices are made of hinged and floor execution with unilateral | maintenance and are intended for installation in rooms with natural ventilation [31].

Nominal mode of operation, long. Devices of automatic switching on of a reserve are intended for operation in industrial, residential, household objects with unilateral service.

Metal structures of ABP devices up to 1200 mm high consist of a shell of frameless construction. Removable hatches are provided for the introduction of cables on the roof and bottom of the shell, a panel is installed inside the structure.

Metal structures with a height of 1400 mm to 2000 mm are made of the shell of the frame structure with sides and top closed with removable plates, inside the frame is installed with mounting panels. Doors in a metalwork are closed by the lock.

Current-carrying parts and wiring inside the cabinet is closed by a metal screen. In a five-wire circuit, two busbars PE and N are installed. Voltmeters and other indications can be used to control the input voltage. Electric meters or network analyzers can be used to record electricity consumption at any time. Electricity is distributed using copper busbars.

Safety requirements meet GOST 19734 and GOST 22789-94, as well as the requirements of "PUE", "Rules of technical operation of consumer electrical installations" approved by the Ministry of Energy, Fire safety requirements meet GOST 12.1.004-85.

Ukrainian engineers have developed and patented a circuit of the ABP device [31], which provides the possibility of uninterrupted operation of electrical equipment and computer network, including without such power supplies. This is because the ABP offered by AS has such little time to switch from main input to backup that it can be used to power even computer networks.

"ABP" from LLC "AS" has the following properties:

speed provides continuous operation of electrical equipment during a power failure at one of the inputs, namely:

switching time of the main input to the reserve - 20ms.

time of switching of reserve input on the main - 15-20ms.

rated operating current 400A, rated mains voltage 380V.

can be installed in buildings where there is no special room for the switchboard.

use of pulse contactors that do not buzz, heat or consume electricity.

impossibility of supply of incomplete phase electric energy to electric receivers (for example: as of two inputs voltage is only on one input and only on 2 phases).

all components of ABP AS of domestic production.

no dependence of the contact pressure on the voltage drop in the network.

the inability to supply voltage to the consumer from two inputs simultaneously.

after applying a voltage pulse lasting 10-20ms, the electromagnetic system acquires the properties of a powerful permanent magnet and keeps the contact group in the closed position indefinitely without consuming electricity for its maintenance.

return to the starting position occurs after the supply of an electrical pulse that removes the magnetic flux.

The fastest ABP device, which in terms of its technical indicators is the closest to that offered by LLC "AS" - is ABP company ASCO (USA).

Switching time from the main input to the backup according to the passport data of ABPO ASCO is 160ms, while the switching "ABP - AC" is 20ms.

Technical characteristics of ABP from the AU (Fig. 4.3):

Checking the compliance of the voltage at the inputs with the following parameters: (amplitude symmetry of the mains voltage; the presence of three phases; compliance with the sequence of phases).

Rated operating current 400A.

Rated voltage of a power circuit 380B, 50Hz.

Switching time of the main input to the backup - 20ms.

Return to the initial state not earlier than in 10 sec, after restoration of network parameters.

Adjusting the shutter speed from 10 to 220 sec

Triggering for 0.02 sec with unacceptable fluctuations of the mains voltage: (sharp voltage increase of more than 60% of the nominal; break of one of the phases).

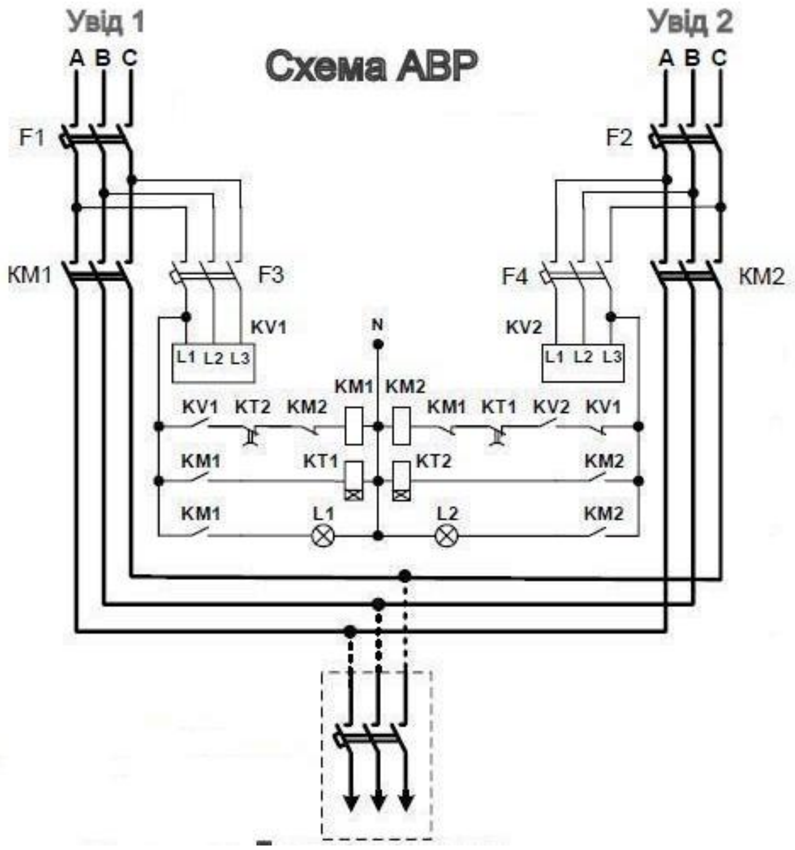


Fig. 4.3. The scheme of the block of automatic inclusion of a reserve.

Triggering for 0.1 sec with unacceptable fluctuations of the mains voltage: (voltage increase above the set U_{max}; voltage decrease by more than 30V from the set Umin).

The allowable value of the amplitude phase shift is 60V.

Range of adjustment of operation on U_{max} / U_{min}, 5 - 25% from nominal.

Delay of operation on U_{min} - 12 sec.

Contactors do not buzz, do not heat and do not consume electricity.

Impossibility of supply of incomplete-phase electric energy to loading (for example: if from two inputs voltage is only on one input and only on 2 phases).

No dependence of the efforts of pressing the contacts on the voltage drop in the network.

Impossibility of supplying voltage to the consumer from two inputs simultaneously.

The operation of the scheme of automatic input of the reserve [31, 32].

Consider the work of ABP in case of failure of input 1.

In the presence of voltage to the switch Q3 contacts 3KV1 and 3KV2 of the voltage relay are opened, not allowing to work the time relay KT1. The disconnectors on the backup input QS5 and QS6 must be switched on and there must be voltage on the backup power buses. When Q3 is switched off, the CT3 time relay is powered. The timer closes its contact in the switching circuit Q6 - its coil YAC 6, which does not work due to the open contact when the Q3 is switched on.

Switching off Q3 is possible by pressing the button or closing the KL contacts in the circuit of the switching coil Q3 –YAT3. The intermediate relay is blocked by its contacts and its disconnection is possible by pressing the 3SBT button. When Q6 is switched on, the possibility of self-disconnection when the current relay KA6 in the relay protection circuit is activated is prepared.

The double set of voltage relays in the circuit is provided to exclude erroneous operation of the circuit due to breakage of wires in the power supply circuit of these relays, blown fuses or damage to one of the phases of voltage transformers.

4.9. Automatic adjustment of the transformation coefficient

In compliance with paragraph 6 of these requirements for the installation of ABP, it is necessary to ensure the maintenance of the required voltage level during operation of the equipment.

In order to maintain the required voltage level on the tires of the smart house room, we use voltage regulation U_n (Fig. 4.4) by changing the transformation coefficient of transformers of step-down substations supplying the distribution network of the dairy [31, 32]. Automatic change n_m is carried out by the ARKT regulator, by means of which the on-load tap-changer is controlled [31, 32].

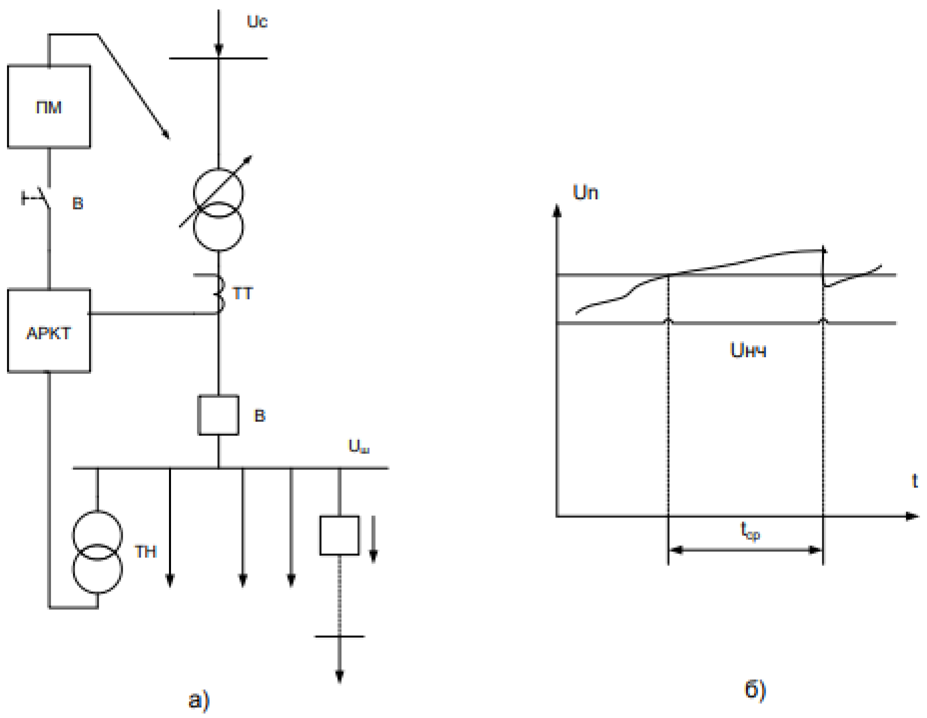


Fig. 4.4. Scheme (a) and voltage characteristics at the terminals of electrical receivers in the presence of ARCT (b).

The lowering substation busbars are branched to provide electricity to a significant number of electrical receivers. We use the method of fixing a constant voltage at some controlled point [32], presenting the network as an equivalent line with one load at the end. Since the value of the voltage U_n at a given voltage on the busbars $U_ш$ depends on the voltage drop in the equivalent line ($U_n = U_ш - Z_{e.л} \cdot I_n$), and the voltage $U_ш$ should be the greater, the greater the load on the consumer. In our case we are talking about counter voltage regulation [31].

The invariance of the voltage in the controlled point of the network at different load modes can be ensured if the input of the measuring instrument to set the ACCT voltage in the control circuit. To do this, it is necessary to apply voltage to it:

$$U_n = U_{ш} - \sigma \cdot I_n,, \tag{4.33}$$

The means of measuring ARCT is a regulator for the deviation of the voltage from the set value $U_{КОНТР}$ (Fig. 5.2), proportional to the voltage at the controlled point. If, $\sigma \cdot I_n$ is equal to the voltage drop in the equivalent line $Z_{e.л}$ (from the bus substation to the controlled point), then in the presence of ARKT voltage at the consumer will correspond to the specified value. That is, it is necessary to enter into the measuring instrument voltage ARKT signal that is proportional to the load current.

It is advisable to use the total load current, because with different schedules of changes in the loads of consumers, the regulation of the total current more precisely corresponds to the required law of regulation.

The measuring instrument is connected to the HV voltage transformer and the vehicle current transformer (Fig. 4.4, a).

When disconnecting the switch B (Fig.4.4, a) ARC must be removed from the work carried out by the auxiliary contact B by disconnecting the output of the ARC from the drive mechanism.

In our case, the power is supplied through two transformer substations, so we install the ACC on the main transformer.

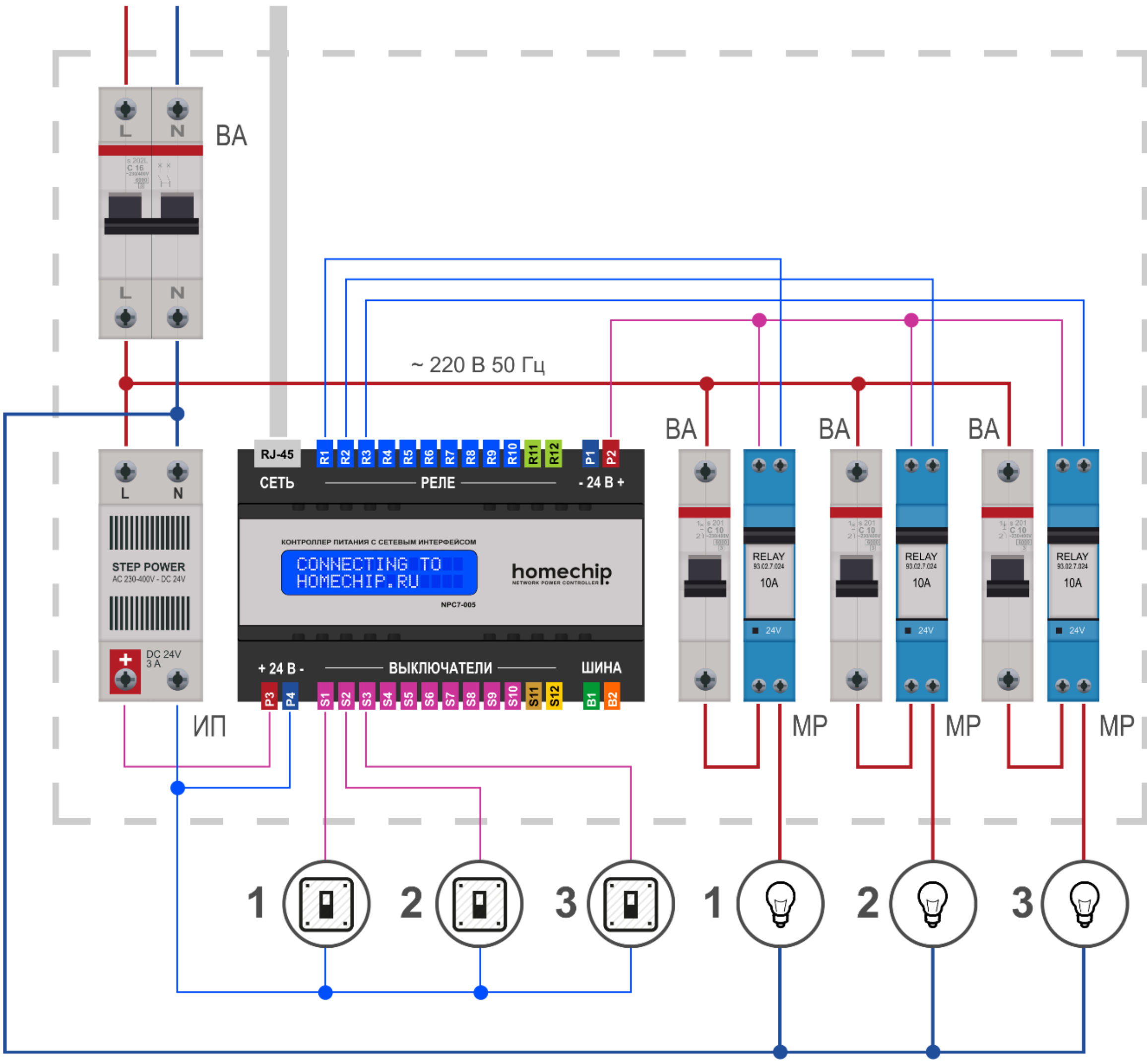
Features of ARCT is the presence of a dead zone $U_{нч}$, which is selected greater than the degree of voltage change $\Delta U_{ст}$ when switching one desoldering:

$$U_{нч} = (1{,}25/1{,}3) \cdot \Delta U_{ст},, \tag{4.34}$$

Switching must be carried out with a time delay, which provides debugging from short-term voltage fluctuations when starting motors. Therefore, when the voltage at the consumer from the insensitivity zone of the regulator (Fig. 5.2, b) ARCT for a time t_{sr} = (1/2) min affects the on-load tap-changer.

4.10. Algorithm of system operation and its structural scheme.

The uninterruptible power supply system of a smart home contains many complex devices, such as generators and batteries, chargers and voltage converters. With their help, the smart control unit monitors and distributes the loads, turns off idle devices in time, thereby extending their life.



Pic 4.5.Controller connection diagram

In addition, the controller monitors the overload of the networks, smoothly changing the voltage in the system, allowing you to save on electricity bills. Thanks to the power supplies included in the system, all devices continue to work even when the mains voltage is cut off (if it is short), since fluctuations are smoothed out. In the absence of current for a long time, backup generators are switched on.

The energy management system includes:

all kinds of meters with an interface (electricity, heat, gas, water) for collecting readings from a distance and sending them by e-mail;

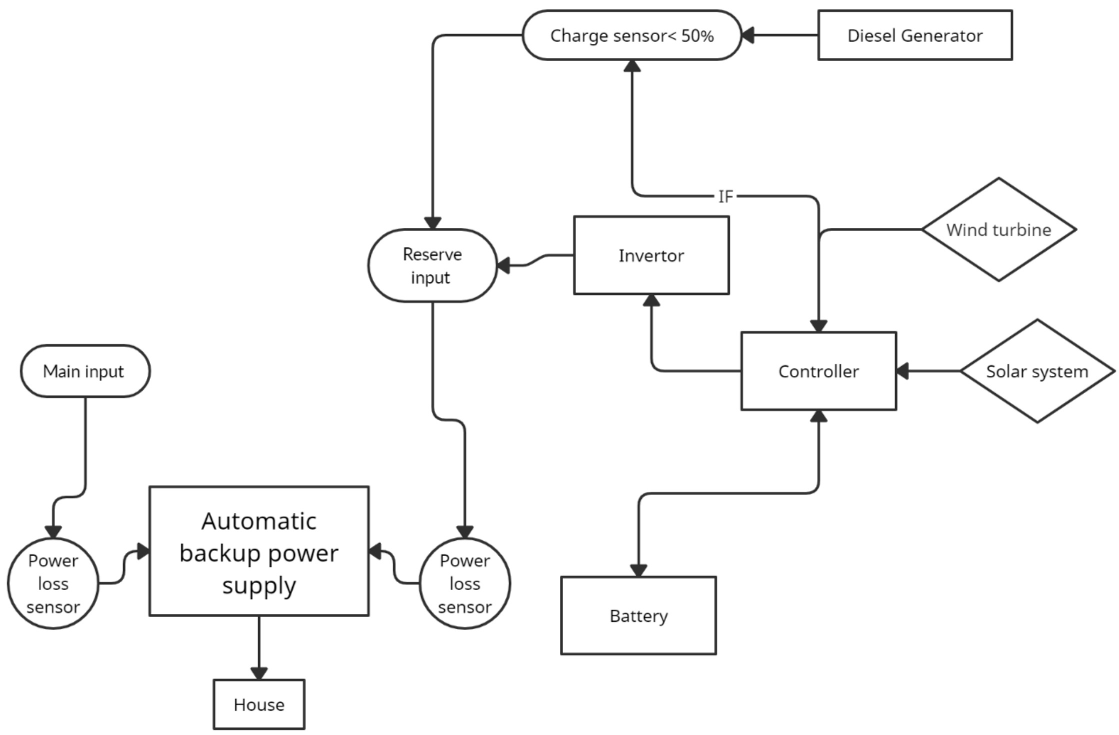
remote control devices over the value of network indicators - current, voltage, power;

sensors for monitoring weather indicators, signaling the closing of windows and transoms in strong winds and cold snaps;

power supply disconnection sensors in emergency situations;

sensors for disconnecting groups of outlets for controlling non-switched off dangerous devices (irons, garlands, etc.);

cloud service that collects, analyzes and stores all parameters.



Pic 4.6. The scheme of power supply of the smart house of the increased reliability

The system consists of: batteries, controller, inverter, solar panel, wind turbine, diesel generator, automatic backup unit, many sensors.

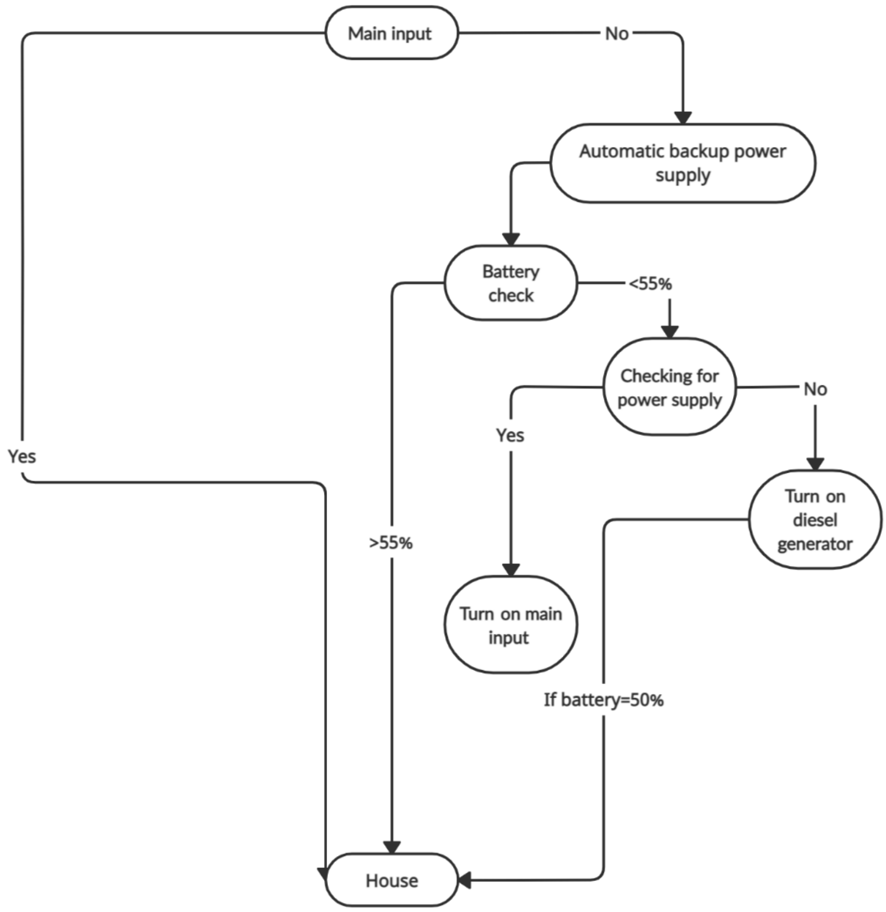
Backup power supply is also designed not only to support the operation of the entire smart home, but also to prevent emergencies, to save equipment from voltage surges. It is a combination of:

uninterruptible power supplies;

alternative sources: wind turbines, solar panels;

diesel or gas generators;

inverters with sufficient battery life.



Pic 4.6. The algorithm systems of power supply of the smart house of the increased reliability

1. Power is supplied from the mains, we apply voltage to the house.
2. There is no power supply from the mains, we start the automatic reserve system.
3. Checking the batteries for the presence of a charge, if the charge is more than 55%, we supply power to the house.
4. If the battery charge is less than 55%, check the availability of the main power grid.
5. If there is no main power grid, start the diesel generator.
6. When the battery reaches 50%, transfer the electricity to the diesel generator.
7. When power appears on the main power grid, the Redundancy Unit switches to it and switches off the diesel generator.

Conclusion to the chapter:

Energy supply and heating systems of a private house using the “smart house” technology, the approximate benefit from the use of this technology has been calculated. The approximate payback period was about 10 years, and the savings on the resources used can reach 45%, and this in conditions of strong inflation can significantly reduce unnecessary costs.

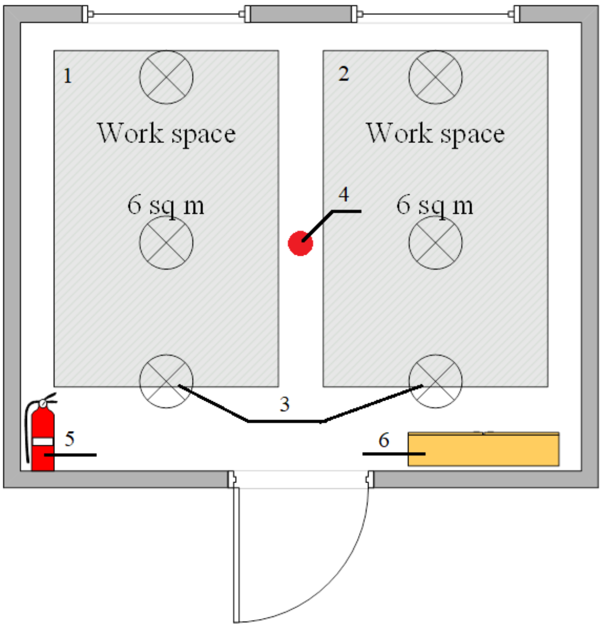
The analysis of construction of systems of automatic input of a reserve at the smart home is carried out and the system of automatic switching on of reserve power supply (ABP) is offered.

The analysis showed that in order to ensure reliability, it is advisable to install an ABP device with the inclusion of a sectional switch.

CHAPTER 5
LABOUR PROTECTION

5.1. Analysis of harmful and dangerous production factors

For the laboratory selected premises with the following geometric parameters: width - 4 m, length - 5 m, area - 20 m^2, ceiling height - 3 m. Building and premises are erected in accordance with the requirements of ДБН В.2.2-28:2010.



1-2 - workspaces, 3 - light sources, 4 - fireproof sensors, 5 - extinguisher, 6 - locker

Figure 6.2.1 Plan of the working premises

«Administrative and household buildings». The laboratory room is equipped with two workplaces for engineers of programmers. The volume of production space per one employee is 18 m^3, the area of the premises equals 6m^2.

The main production process consists in developing algorithms, writing software for an automatized system of autonomous power supply of smart house of increased reliability that requires the use of a computer, testing on the simulator and preparing the relevant technical documentation.

There are four workstations in the room. All of them are equipped with PCs with liquid crystal monitors connected to the local network. An additional phone, printer is installed on the table. The lighting of the room is carried out with the help of fluorescent lamps, the feature of which is high-frequency flickering and creating noise during work, which in turn does not provide comfortable conditions for work in the room.

The work of the software engineer is associated with significant visual load, and, as a consequence, requires adequate lighting; and also related to the use of computers, which is a source of increased noise in the workplace, as well as a source of non-ionizing electromagnetic fields and radiation. The work of the software developer is related to the permanent presence of the worker indoors, therefore, in order to ensure comfortable and healthy working conditions, it is necessary to create a proper microclimate in the laboratory. It is worth noting that the work of the software engineer is tense, since it requires maximum concentration to solve complex tasks and long-term monitoring of video terminals, and the worker is responsible for the functional quality of the main work; so the noise generated by a computer can negatively affect the performance of an employee.

Then, according to the standard ГОСТ 12.0.003-74:

Physical hazards and harmful factors include:

- insufficient lighting of the working area;
- electronic shock when working on faulty equipment;
- increased levels of infrared radiation;
- increased levels of ultraviolet radiation.

Psychophysiological dangerous and harmful production factors include:

- physical overload (static and dynamic)
- neuropsychiatric overload (overstrain of the visual organs, emotional overload)

Lighting in the workplace of the software developer must be such that the worker can perform his work without excessive visual tension. In order to provide the necessary characteristics of artificial lighting, it is necessary to install the required number of lighting devices that will ensure compliance with the norms prescribed in ДБН В.2.5-28-2006 "Natural and Artificial Lighting".

The calculation of the illumination of the workplace is reduced to the choice of lighting system, the definition of the required number of lighting devices of a certain type, and their placement. The process of the programmer's work in conditions where natural light is insufficient or absent. Proceeding from this, we calculate the parameters of artificial lighting.

To improve the working conditions of the laboratory staff and to reduce the energy consumption, replace the fluorescent lamps on the LED.

As a lighting device, LED lamps T8 LED G13 20W 150sm were chosen. Voltage of the lighting network - 220V, power supply - domestic electricity 220V, 50Hz.

This room does not belong to those which need emergency and next lighting according to ДБН В.2.5-28-2006 "Natural and artificial lighting”.

Microclimate of the working zone**.** According to ГН 3.3.5-8-6.6.12014 "Hygienic classification of labor on the indicators of safety and insecurity of the factors of the production environment, the difficulty and intensity of the labor process," the work of a programmer engineer relates to the optimal (light physical activity) severity.

The main document regulating the norms of the microclimate of the working zone is ДСН 3.3.6.042-99 "Sanitary norms of the microclimate of industrial premises".

The values of the parameters of the optimal and acceptable parameters of the microclimate according to the ДСН 3.3.6.042-99 "Sanitary norms of the microclimate of the industrial premises" for the premises, and the actual parameters presented in Table 6.1.

Table 6.1.

Time of the year	Microclimate parameter	Value		
		Optimal	Allowable	Actual
Cold	Air temperature inside the building	22-24°C	25-21°C	23°C
	Relative humidity	60 - 40%	75%	45%

	Airflow speed	0,1m/s	up to 0,1m/s	0,1 m/s
Warm	Air temperature inside the building	23 - 25°C	28-22°C	29°C
	Relative humidity	60 - 40%	55% on t=28°C	55%
	Airflow speed	0,1 м/с	0,2-0,1 m/s	0,1 m/s

The actual temperature in the room during the warm period (29 ° C) does not fall within the range of valid values ranging from 22 to 28 ° C. Consequently, during the warm season, it is necessary to use an air conditioner in the room; As the optimal in terms of price-quality ratio, it is proposed to use the split system Samurai SMA-07HRN1 ION.

Increased noise level on workspace. Noise level in the computer lab is increased, caused by two PCs, two telephone faxes, a printer, and a buzz of the trigger relay of fixtures. Acceptable levels of sound pressure in octave frequency bands, equivalent to sound levels at workplaces, are regulated by the ДСН 3.3.6.037-99 "Sanitary norms of production noise, ultrasound and infrasound". Acceptable equivalent sound level for scientific activity is 50 dBA.

Noise worsens the working conditions by harmful effects on the human body. Working in conditions of prolonged noise, the worker begins to feel irritability, headaches, dizziness, memory loss, increased fatigue, loss of appetite, pain in the ears, etc. Such violations in the work of a number of organs and systems of the human body can cause negative changes in the emotional state of the person up to stressful situations. Under the influence of noise, concentration of attention decreases, physiological functions are violated, tiredness arises due to increased energy expenditure and nervous-psychic tension, language switching is worsening. All this reduces the efficiency of a person and his productivity, quality and safety of work.

To reduce the noise level, additional sound insulation is required. As soundproofing materials used in structural ceilings to reduce the transmission of structural (shock) sound, mainly use mats and slabs of glass and mineral fiber, soft boards of wood shavings, cardboard, rubber, insulated linoleum, as well as replacement of windows for soundproofing . Replacing the fluorescent light on the LED will also reduce the noise level in the room.

5.2. Measures to reduce the impact of harmful and dangerous production factors

To calculate the lighting of the room we use the method of light flow. To determine the number of fixtures we determine the light flux falling on the surface according to the formula: $F=EKSZ$, where F - light flux, *Lm*; E - normalized optimal lighting, *Lux*, $E=400$ *Lux;* S - area of the illuminated room ($S = 20\ m^2$); Z - relation of average lighting to the minimal ($Z = 1.1$); K - factor of the stock taking into account the decrease of the light flux of the lamp as a result of pollution of the lamps during the operation (its value is determined from the table of stock ratios for different premises, for LED lamps $K = 1$); η - coefficient of use (expressed as the ratio of the light flux falling on the calculated surface to the total flow of all lamps and is calculated in units of unit; depends on the characteristics of the lamp, the size of the room, the coloring of the floor, walls and ceilings, which are characterized by the coefficients of reflection from the floor (RPD) walls (Pc) and ceiling (Pst)), the values of the coefficients Ppd, Pc and Pst are determined from the table of dependences of the coefficients of reflection on the nature of the surface, the room is light, with white walls, light monochrome wallpapers, n laminate floor gray: PC = 50%, PCT = 70% = 30% RAP. The value of η is determined from the table of coefficients of use of different fixtures. To do this, we calculate the index of the premises by the formula:

$$I = \frac{S}{h \cdot (A+B)},$$

Where S - surface square, $S = 20\ м^2$; h - the design height of the suspension above the working surface, $h = 2,2\ m$; A - accommodation width, $A = 4\ m$; B - accommodation height, $B = 5$ m.

Substituting the values we obtain:

$$I = 202.2 \cdot (4 + 5) = 1$$

Knowing the index of the premises I, Pdd, Pc and Pst, the value of η = 0.43.

We substitute all values in the formula for determining the light flux F:

$$F = 4001.1201.10.43 = 22512\ Lm$$

For lighting, we choose LED lamps T8 LED G13 20W 150cm light flux of which Fl = 2400 lm. Calculate the required number of lamps by the formula:

$$N = \frac{F}{F_L},$$

where *N* - lamps quantity required; *F = 22512 Lm* - lighting flux; F_L - lamp lighting flux, F_L *= 2400 Lm*.

$$N = 225122400 = 10\ pcs$$

So, for lighting we use 5 fixtures, each lamp is equipped with two lamps.

5.3. Occupational Safety Instruction

TERMS

1.1. The instruction is developed on the basis of ДНАОП 0.00-8.03-93 "The order of working out and the statement by the owner of regulations on labor protection operating at the enterprise", ДНАОП 0.00-4.15-98 "Regulations on development of instructions on labor protection", ДНАОП 0.00-4.12-99 "Typical provision on labor protection training".

1.2. This instruction sets out general health and safety requirements for the programmer.

1.3. All work performed by the programmer must be performed in accordance with these instructions.

1.4. The workplace throughout the work shift for the programmer is a specially equipped place.

1.5. Persons who have undergone training, internships, instruction on occupational safety, including in the performance of high-risk work, familiar with the rules of conduct in the event of accidents and first aid to victims of accidents in accordance with the requirements of the Standard Regulations training and testing of knowledge on labor protection, approved by the order of the State Labor Inspectorate of Ukraine dated 26.01.2005 № 15, registered in the Ministry of Justice of Ukraine on 15.02.2005 for № 231/10511 (НПАОП 0.00-4.12-05).

1.9. The programmer's work schedule is set according to the rules of internal labor regulations.

1.10. The programmer must:

- take care of personal safety and health, as well as the safety and health of others in the process of performing any work or while on the premises of the enterprise;
- know and follow the requirements of the instructions on labor protection and types of work at your workplace;
- perform work in accordance with the requirements of the instructional and technological map;
- be able to use the means of individual and collective protection;
- know and follow the Rules of handling equipment, inventory, use the technical passport for the equipment;
- know and perform the duties of labor protection provided by the collective agreement (employment agreement), the rules of internal labor regulations of the enterprise, including:
- start and finish work on time, follow the schedule of technological and lunch breaks;
- not to perform work that is not provided by the variable task;
- not to be at work during non-working hours without the appropriate order of the head;
- follow the rules of corporate conduct;
- undergo medical examinations in the prescribed manner;
- be able to provide first aid to the victim of an accident;
- before the start of work to check up serviceability of the equipment, protections, engineering and technical means of safety, stock, means of fire extinguishing;
- cooperate with the employer in the organization of safe and harmless working conditions, personally take possible measures to eliminate any situation that threatens her life or health or people around her and the natural environment;

- in case of deficiencies or dangers, it is obliged to inform the immediate supervisor or another official.

GENERAL SAFETY REQUIREMENTS BEFORE WORK

2.1. Verify:

- serviceability of equipment, tools, devices;
- availability and serviceability of sufficient lighting, ventilation, equipment, etc;
- check the serviceability of switches, sockets, plugs, etc.

2.2. In case of detection of any deviations, malfunctions, damages to inform the director of the Enterprise immediately.

GENERAL SAFETY REQUIREMENTS DURING THE WORK

3.1. Perform work in accordance with your job responsibilities.

3.2. Do not leave your workplace unattended when the equipment is connected to the mains.

3.3. In case of detection of any deviations, malfunctions, damages to inform the director of the Enterprise immediately.

SAFETY REQUIREMENTS AFTER THE END OF WORK.

4.1. Check your workplace.

4.2. Disconnect electrical equipment from the mains.

4.3. Close the windows.

4.4. Take personal hygiene measures: wash your hands thoroughly, if possible take a shower.

4.5. Put in order special clothes, remove and put it in a separate place.

SAFETY REQUIREMENTS IN AN EMERGENCY SITUATION

5.1. If a dangerous situation is detected (fire, earthquake, radiation safety, electrical problems, etc.) for their own lives and the lives of employees to calm and reassure others.

5.2. Do not troubleshoot the power supply and electrical equipment yourself, but turn off the general power supply.

5.3. If a fire is detected, he must call the fire department immediately.

5.4. Take measures in accordance with the evacuation plan in case of fire, industrial and natural phenomena and bring workers to safety. Organize the work of the DPD on the preservation of property and securities.

5.5. In the event of an outsider who uses illegal actions for the safety of others, call the police.

5.6. In case of injury to employees or customers during the operation of the enterprise it is necessary to call an ambulance or, if necessary, provide first aid, if necessary to create a commission to investigate the accident, issue a standard act, order the results of the investigation, notification of the accident.

5.7. Actions in providing first aid. The provision of first aid begins with an assessment of the general condition of the victim and on this basis to form an opinion about the nature of the injury.

In case of severe disturbance or lack of breathing, cardiac arrest, immediately perform artificial respiration and external cardiac massage, call an ambulance.

5.8 .. Actions in case of electric shock:

it is necessary to release the victim from the action of electric current by disconnecting the electrical equipment from the power supply, and if it is impossible to disconnect - to pull it away from the live parts for clothing or using improvised insulating material;

in the absence of the victim's breathing and pulse, it is necessary to give him artificial respiration and indirect (external) heart massage, paying attention to the pupils. Dilated pupils indicate a sharp deterioration in cerebral circulation. In this condition, resuscitation should begin immediately, then call an ambulance.

5.9. Actions in case of injury:

to provide first aid for an injury, it is necessary to open an individual package, apply a sterile dressing to the wound and tie it with a bandage;

if there is no individual package, a clean handkerchief, a clean linen cloth, etc. should be used for dressing. In the place of the rag that falls directly on the wound, it is desirable to drip a few drops of iodine tincture to get a stain larger than the wound, and then apply a rag to the wound.

5.10. Actions for fractures, dislocations, strokes, sprains:

at fractures and dislocations of extremities it is necessary to strengthen the damaged extremity by the tire, a plywood plate, a stick, a cardboard or other similar subject. The injured arm can also be hung around the neck with a bandage or handkerchief and bandaged to the torso; • in case of a presumed skull fracture (unconsciousness after a blow to the head, bleeding from the ears or mouth) it is necessary to apply a cold object (a warmer with ice or snow or cold water) to the head or make a cold lotion;

if a fracture of the spine is suspected, the victim should be placed on a board without lifting it, or the victim should be turned face down on the abdomen, making sure that the torso is not bent in order to avoid spinal cord injury;

in case of rib fracture, which is a sign of pain when breathing, coughing, sneezing, movements, it is necessary to tightly bandage the chest or tighten them with a towel during exhalation.

5.11. Actions for heat burns:

in case of fire burns, steam, hot objects should never be used to open the blisters that form and bandage the burns;

at burns of the first degree (reddening) the burnt place is processed by the cotton wool moistened with ethyl alcohol; at second-degree burns (blisters) the burnt place is treated with alcohol, 3% manganese solution or 4% tannin solution;

for third-degree burns (destruction of skin tissue), cover the wound with a sterile bandage and call a doctor.

Conclusions to the chapter:

This chapter discusses the requirements of industrial and environmental safety and developed a number of recommendations for the optimal sanitary and hygienic environment for the work of a design engineer with a personal computer.

1. Luminescent lamps in the room created noise and high-frequency flicker, which resulted in unsatisfactory working conditions, to ensure optimal illumination of 400k, improve working conditions and reduce the use of electricity used 5 lights with 2 LED lamps T8 LED G13 20W 150cm each.

2. The actual value of the air temperature in the room during the warm period is 29°C, which according to is the DSN 3.3.6.042-99 "Sanitary norms of the microclimate of industrial premises" is not included in the optimal range, for the normalization of temperature control of air it is suggested to use the split system Samurai SMA-07HRN1 ION.

Thus, having understood the essence of the phenomena, assessing their possible danger, having familiarized himself with the normative materials, the programmer working with the system can skillfully find ways and methods of work that will avoid injuries, occupational diseases and eliminate the influence of hazardous and harmful influences on the working organism.

CHAPTER 6
ENVIRONMENTAL PROTECTION

6.1. Scope

For a smart home, the best power is from renewable sources. Renewable energy is a promising alternative to fossil fuel-based energy, but its development may require a complex set of environmental trade-offs. The recent increase in the number of solar energy systems, especially large centralized installations, underscores the need to understand their interaction with the environment. Summarizing the literature across multiple disciplines, we analyze the direct and indirect environmental impacts — both beneficial and adverse — of solar utility development (USSE), including biodiversity impacts, changes in land use and land cover, soil, water resources. and human health. In addition, we analyze the feedback between the USSE infrastructure and the interactions between the earth and the atmosphere and the potential for USSE systems to mitigate climate change. Some of the characteristics and development strategies of USSE systems have a low environmental impact compared to other energy systems, including other renewable energy sources. We show opportunities to increase the concomitant environmental benefits of the USSE, permissive and regulatory restrictions and USSE capabilities, and highlight future research directions to better understand the relationship between the USSE and the environment. Improving the environmental compatibility of USSE systems will maximize the effectiveness of this key source of renewable energy in mitigating climate and global environmental changes.

Renewable energy is on the rise, largely to reduce dependency on limited reserves of fossil fuels and to mitigate impacts of climate change. The generation of electricity from sunlight directly (photovoltaic) and indirectly (concentrating solar power) over the last decade has been growing exponentially worldwide.

This is not surprising as the sun can provide more than 2500 terawatts (TW) of technically accessible energy over large areas of Earth′s surface and solar energy technologies are no longer cost prohibitive. In fact, solar power technology dwarfs the potential of other renewable energy technologies such as wind- and biomass-derived energy by several orders of magnitude. Moreover, solar energy has several positive aspects – reduction of greenhouse gases, stabilization of degraded land, increased energy independence, job opportunities, acceleration of rural electrification, and improved quality of life in developing countries – that make it attractive in diverse regions worldwide.

Extensive consumption of fossil fuels in almost all human activities has led to some undesirable phenomena, such as pollution of the atmosphere and the environment, which were not previously known in human history. Consequently, global warming, the greenhouse effect, climate change, depletion of the ozone layer and the terminology of acid rain began to appear frequently in the literature. Since 1970, experiments and studies have taught us to understand that these phenomena are closely related to the use of fossil fuels, since they emit greenhouse gases such as carbon dioxide (CO2) and methane (CH4), which impede the release of long-wave earth radiation into space, and therefore, the Earth's troposphere is getting warmer. To avoid further effects of these phenomena, the two concentrated alternatives must either improve the quality of fossil fuels with a reduction in their harmful emissions to the atmosphere, or, more importantly, replace the use of fossil fuels with as much clean, clean and renewable energy sources as possible. Among these sources, solar energy ranks first on the list due to its abundance and more even distribution in nature than any other type of renewable energy, such as wind, geothermal, hydro, wave and tidal energy (Sen, 2004).

Solar energy technologies are important components of a sustainable energy future. Fossil fuel energy can be inexpensive and may have been given guarantees for abundant oil and other fossil fuels, but these fuels are limited and are a major source of greenhouse gas emissions (IEA, 2002).

As energy demands increase, energy production and its negative impact on the environment increase. As a result, environmental pollution has become a global threat. Thus, the importance of uncontaminated energy sources, such as solar energy, has increased in recent years. But even solar energy technologies have introduced some level of environmental impact. In this chapter, these effects will be discussed and the necessary conditions investigated to avoid this environmental impact.

6.2. Solar Energy Systems

1. Solar Energy

Since time immemorial, solar energy has been used to dry agricultural products, to heat premises during the cold season, or to create ventilation in homes, applications that are still used in many developing countries. More than 2000 years ago, Gerona of Alexandria built a simple water pump powered by solar energy, and in 214 BC. E. Archimedes of Syracuse used concentrating solar mirrors to set fire to Roman ships.

The sun waters the earth with an almost endless supply of energy. Every day more solar energy falls on the earth than the total amount of energy that 5.9 billion people on the planet would have consumed in 27 years. Although it is impossible and impossible to use this small part of this energy, the potential of solar energy has practically not been used. Only in the last few decades, when growing energy needs, growing environmental problems and declining fossil fuel resources have led us to look at alternative energy options, the focus has been on genuine exploitation of this huge resource (NREL, 2002).

The sun is the main source of energy of the Earth. Almost all natural sources of energy (with the exception of nuclear and geothermal energy) on Earth are transformed forms of solar energy. For example, the water cycle, wind cycle, and other energy systems require solar energy as the main source of movement. Due to the fact that the solar energy system is a relatively environmentally friendly form of energy, in recent years it has been widely used. It is also a relatively infinite source of energy compared to fossil forms of energy.

2. Solar Collectors

There are basically three types of collectors: flat-plate, evacuated-tube, and concentrating. Flat-plate collectors are the most commonly used types.

1) Flat collectors. The basic principle of operation of these collectors is based on the conversion of solar energy into thermal energy. Flat collectors are made of a glass cover in the form of a transparent material, the absorbing plate and the housing. The radiation transmitted through the glass plate is absorbed by the solar plate. This plate is covered with paints or special surfaces for high absorbent properties. Almost 90 % of the solar radiation felt on the surface is absorbed by these plates. The rest are radiated back as thermal radiation and convective losses.

2) Concentrating collectors: these collectors are used to produce water with higher enthalpy or other process fluids. Usually temperatures above 140 ° C cannot be obtained using flat solar collectors, and concentrating collectors are used at temperatures above 140 ° C. Concentration collectors consist of two components: the optical system and the receiver. The function of the optical system is to direct and focus the sun's rays on the receiver. The function of the receiver is to absorb the sun's rays and convert them into thermal energy. The receiver consists of absorber, protection and insulation. The ratio of open space for the sun to the space of the receiver where the sun will be absorbed is called the condensation coefficient. Concentration collectors can be classified according to their condensation coefficients:

- flat receiver and flat reflectors
- pipe or spherical-shaped receiver and parabolic reflectors
- pipe or spherical-shaped receiver and flat, moving reflectors in separate rows
- pipe or spherical-shaped receiver and flat, single-moving reflectors.

3) Evacuated-tube collectors: Evacuated tubes are the absorber of the solar water heater. They absorb solar energy converting it into heat for use in water heating. Evacuated tubes have already been used for years in Germany, Canada, China, and the UK. There are several types of evacuated tubes in use in the solar industry.

3. <u>Solar Heating</u>

   1. Active heating systems: There are examples of solar active heating systems, like heating the water by solar collectors and the transmission of heated water to the existing central heating installation, and thus the transportation of heated air for needed areas.
   2. Passive heating systems: Passive heating systems using solar energy operate as a ray trap. Solar radiation enters a covered volume through glass and similar transparent materials and is absorbed by some absorbing surfaces. The heated surfaces radiate energy by radiation, but these heat rays cannot pass through the glass surface where sunrays can get through. Thus, the heat energy carried by the solar rays is kept inside.

4. <u>Drying Using Solar Energy</u>

The drying process can be defined as the removal of water from a solid substance by evaporation. When the energy needed by this process is supplied by solar energy, this is called “drying using solar energy.”

Solar drying is one of the oldest solar applications of mankind. The simplest solar dryer, at zero cost, is a black asphalt road on which people spread their grains to increase the natural (solar) drying process (NREL, 2002).

5. Electrical Energy Converters

1) Solar cells. Solar cells are systems that convert the sun's rays into electricity. The radiation energy emitted in the form of electromagnetic waves reaching the surface of solar cells causes a photoelectromotive force through the formation of electron / deviation pairs during the transition of P-N semiconductor crystals. These pairs are separated in the electrical region during the P-N junction and, thus, cause a current in the circuit that was connected to the semiconducting crystal.

2) Thermal solar energy systems: in these systems, solar radiation is concentrated by some concentrators and boiled with a working fluid that goes into a heat cycle (the Rankine cycle is the most common, although Ka-li and similar multifluid working fluid cycles start to occur) created in a thermal cycle, is converted into electricity using an electric generator. Another form of thermal solar power system can convert solar energy into hydrocarbon fuel, and stored hydrocarbon fuel can be converted into electrical energy by installing an internal combustion engine generator.

6. Environmental Impact Assessment

The importance of the concept of sustainable development has increased in Turkey, as well as throughout the world. As a result, some new rules prescribe that all development projects are compatible with environmental criteria. An environmental impact assessment should be carried out to ensure that projects are compatible with environmental criteria. Environmental impact assessment (EIA) can be defined as the process of environmental management, planning and decision-making with the aim of preserving and improving the quality of the environment. The main goal is the development of environmentally friendly industrialization. With this type of environmentally friendly industrialization, “sustainable development” may become possible in the future, maintaining a balance between use and protection between economic development and environmental protection.

The EIA rules in Turkey entered into force in the official newspaper of 02/02/1993, no. 21489, and the EIA rules of 1993, 1997, 2002 and 2003 were observed.

Solar energy systems are environmentally friendly systems. However, solar energy system designs still need to undergo an EIA process and thus help minimize potential negative environmental impacts (EIA, 2006).

7. Environmental Impacts from the Solar Energy Systems in the Example of Solar Cells

Solar energy is a lot cleaner when compared with conventional energy sources. Solar energy systems have many significant advantages, like being cheaper and not producing any pollutants during operation, and being almost an infinite energy source when compared with fossil fuels. Nevertheless, solar energy systems have some certain negative impacts on the environment just like any other energy system. Some of these impacts will be summarized in this section.

8. Human health and air quality

As in the case of the development of any large industrial facility, the construction of USSE power plants may pose a threat to air quality, the health of plant workers and the public. Such hazards include the release of pathogenic microorganisms in the soil, an increase in the amount of particulate matter in the air and reduced visibility for drivers on nearby roads, as well as pollution of water bodies. For example, soil disturbance in the arid regions of America and Europe, which are objects intended for the USSE, contributes to the transmission of Coccidioides immitis, a fungus that causes valley fever in humans. In places where there are traces of chemical and radioactive contamination on the surface of the soil (for example, radionucleotides, agrochemical residues), increased eolian transport as a result of soil disturbances increases the concentration of pollutants in dust in the air.

During the decommissioning phase, PV cells can be recycled to prevent environmental contamination due to toxic materials contained within the cell, including cadmium, arsenic, and silica dust. In the case of inappropriate handling or damaged cells, these industrial wastes can become exposed, which can be hazardous to the public and environment. For example, inhalation of silica dust over long periods of time can lead to silicosis, a disease that causes scar tissue in the lungs and respiratory decline. In severe cases, it can be fatal. In addition, chemical spills of materials such as dust suppressants, coolant liquids, heat transfer fluids, and herbicides can pollute surface ground water and deep water reservoirs.

On the roofs of solar panels, it has also been shown that solar photovoltaic panels reduce heat flux on the roof, save energy and increase human comfort from cooling. In this vein, the insulating properties of a solar photovoltaic system on the roof can serve as a co-benefit to reduce the diseases and deaths associated with heat waves. The fire hazard potential for both USSE roof and ground infrastructure materials (eg, phosphine, diborane, cadmium) and their proper disposal presents an additional challenge to minimize the environmental impact of USSE facilities. This is especially true in light of the sharp increase in the frequency and intensity of wildland fires in arid and semi-arid regions of the world as a result of climate change.

9. Comparing land-use across all energy systems

Land-use and land-cover change impacts from USSE are relatively small when compared to other energy systems. In five ecosystems in western Europe, Copeland et al. found that actively producing oil and gas leases impact 5.7 million ha of land (4.5% of each terrestrial ecosystem evaluated) but the total potential for lands to be disturbed exceeded 25 million ha (11.1%). In contrast, potential land-cover change impacts from USSE development was <1% of all ecosystems combined. In terms of land-use efficiency, PV energy systems generate the greatest amount of power per area among renewables, including wind, hydroelectric, and biomass. Notably, ground-mounted PV installations have a higher land use efficiency (when incorporating both direct and indirect effects [e.g., resource extraction]) than surface coal mining, which is how 70% of all coal in the Europe is extracted. These results underscore the environmental potential solar energy development may have on landcover and land-use change impacts, relative to carbon-intensive energy and other renewable energy sources.

10. Utility-scale solar energy and climate change

Harder our understanding of the interaction of the Earth and the atmosphere with the USSE is climate change. Perhaps one of the biggest problems with the deployment of these facilities will be the expectation of a reduction in water resources in areas that are already experiencing water scarcity. In 2009, all active CSP facilities in the USA were wet cooled. Reducing the availability of water will have implications for the operation of the USSE facility, as well as for the deposition of dust on mirrors or panels (scaled and distributed). In places where more frequent intense storms may occur, the immediate problem will be related to the operational and environmental consequences of erosion.

Another part of the problem is climate change and extreme weather events. Photovoltaic technologies use both direct and diffused light to convert solar energy into electricity, but high ambient temperatures reduce the efficiency of the panel almost linearly. Consequently, cool places with high illumination are the best places for shooting solar energy with PV. Currently, the cumulative uncertainty (i.e., standard deviation) of the PV output is about 8% over the lifetime of the PV system. Uncertainty may increase if climate change predictions are taken into account. The concentration of solar energy increases linearly with increasing ambient temperature and is proportional to direct illumination, and therefore climate change also affects CSP performance. In fact, the favorable conditions for PV and CSP at specific sites are projected to change over time under different climate change scenarios; for example, CSP could increase to 10% in Europe under the scenario of the Intergovernmental Panel on Climate Change A1B.

Replacing energy-intensive sources of energy with solar energy has tremendous potential to mitigate the effects of climate change by directly reducing greenhouse gas emissions. In the US, Zhai et al. simulated a reduction in CO2 emissions from 6.5% to 18.8% if PV was 10% of the grid. Recently, a series of studies have harmonized (that is, standardized and performed a meta-analysis of data from a large number of studies) current literature on life cycle analysis for estimating greenhouse gas emissions during the life cycle from various solar technologies, including upstream (for example, purchasing raw materials, production), operational and subsequent processes (for example, sales and distribution of a product, decommissioning and disposal). Photovoltaic solar technologies ranged from 14 to 45 g CO2-eq. KW · h, where CO2-eq. is the equivalent of carbon dioxide, a measure to quantify the impact of greenhouse gases on climate by rationing the amount equivalent to CO2. The concentration of solar energy ranged from 26 to 38 g CO2-eq. KW · h for a parabolic trough and power tower, respectively. These emission values were an order of magnitude less than greenhouse gas emissions from coal, gas or oil Varun and Parkas.

11. Land Use and Thermal Pollution

Solar cells (photovoltaic) have a different impact on the natural ecosystem. These impacts are related to some specific factors, such as the area and terrain to be covered, sensitive ecosystems and biodiversity. The use of solar cells on cultivated land can cause possible damage to productive areas of the earth. Large-scale land use also affects the heat balance of the area, absorbing more energy from the earth than would otherwise be reflected from the surface back into space. Serious use of solar energy should use square kilometers of desert territory. The heat balance of this land space can certainly be achieved with such an application. In addition, additional heat can destroy several species that live in such harsh conditions. To avoid such a large use of the earth, space solar power plants are also taken into account, but the energy of these systems must be transmitted to the earth in the form of microwaves, which can cause radiation pollution and endanger the life of birds passing through the irradiated zone.

12. Discharge of Pollutants

Solar cells do not emit pollutants during their work. But solar cell modules contain some toxic substances, and there is a potential risk of these chemicals being released into the environment during a fire. Necessary precautions must be taken in emergency situations such as fire. The possibility of accidental release of chemical modules of solar cells into the soil and groundwater poses a great threat to the environment.

13. Visual Impacts

There will be some visual effects depending on the type of circuit and the environment of the solar cells. Especially for building applications, solar cells can be used as a cladding material that can be built into a building during the construction phase. The use of solar panels after the construction phase of a building can cause a negative visual impact. The use of solar panels should be planned at the architectural stage and installed on the building to minimize visual pollution. For other applications, proper placement and design are important factors, especially for large solar cells. Another important factor in controlling visual impact is the use of color. When assembling solar cell modules, sufficient care should be taken when using the correct colors.

14. Impacts on Natural Resources

Despite being a benign energy system during operation, solar cells have some negative impacts on the environment during their production phase like many other systems. The energy needed for the production of solar energy systems is still produced in conventional methods today. Some toxic chemical substances used during the production phase are produced as a by-product. Especially, the solar cell batteries pose a threat on natural resources by having a short lifespan and containing heavy metals such as cadmium.

15. Air Pollution

Solar cells do not release any substances into the air during operation. But there may be some emissions from production and transportation. Emissions associated with the transportation of modules are insignificant compared to emissions associated with production. Vehicle emissions account for 0.1–1% of production emissions. For polycrystalline and single crystal modules, the estimated emissions are 2.757–3.845 kg CO_2 / kWh, 5.049–5.524 kg SO_2 / kWh and 4.507–5.273 NO_x / kWh (kW / h: peak kilowatt).

16. Noise Intrusion

Solar cells do not make a noise during operation. But during the construction phase, there will be a little noise as usual in other construction activities.

17. Visual Burdens

The urbanization process, which has accelerated with industrialization, has brought several problems that put pressure on the environment, despite many useful achievements. With the exception of specific problems, such as air, soil and water pollution, a new fact of pollution has emerged due to visual burden and noise, which burden the psychological structure rather than the physical and chemical structures of the human body.

Visual loads can be defined as irregular forms that usually exist in the natural and cultural environment, which mostly appear indirectly and cause negative characters in human memory. The visual burden mainly has a psychological effect on a person, but can affect the physical structure of the environment and even can stop some of the functions of the environment.

Today, the visual burden has become a big problem due to the lack of support for long-term planning in the urbanization process. Recently, the need for home use of solar thermal energy systems has increased, but these systems cause an increase in visual burden due to insufficient legal regime and the lack of public awareness. Since there are good examples of solar energy systems that integrate into buildings during the construction phase (Figure 6.1.), in Turkey these systems usually connect to buildings after the construction phase and thus degrade the already poor visual quality of these buildings.

Figure 6.1. An example of solar cells that do not cause visual loads.

Figure 6.2. An example of solar cells that do not cause visual loads.

To prevent the visual burdens of the solar energy systems on the buildings, a professional group should be hired, and solar energy systems should be integrated with the building during the construction phase, with proper planning and application. But, if there are necessary situations where solar energy systems should be attached to buildings after construction, giving these systems an aesthetic form could be a short-term solution. Especially for the apartment houses where roof space isn’t large enough for solar energy systems of each of the flats, these personal systems should be evaded and a central system should be chosen. It is obvious that these systems should be standardized and the community should be educated (Al, 1995).

Conclusions and Recommendations

So, for a smart home, the best power is from renewable sources. Solar energy is becoming increasingly important as an alternative source of energy. Today it has become indispensable due to the fact that it is an environmentally friendly and endless source of energy. But solar energy systems have some impact on the environment. These potential impacts depend on the size and nature of the project and depend on the specific site. Most of these problems are related to the loss of amenities.

Communal-scale energy systems are on the rise worldwide, due to technological progress, political changes and the urgent need to reduce both our dependence on carbon-intensive energy sources and the emission of greenhouse gases into the atmosphere. Recently, the growing interest of scientists, solar developers, land surveyors and politicians in understanding the USSE's environmental impact — both positive and negative — from a local to a global scale, has generated new research and results. This review synthesizes this body of knowledge, which conceptually covers numerous disciplines and crosses many interdisciplinary boundaries.

The adverse impact of the USSE on the environment has not yet been carefully evaluated and weighed in view of the many environmental benefits, in particular, climate change mitigation, and the co-benefits that solar energy systems offer. Indeed, some of the characteristics and development strategies of USSE systems have a low environmental impact compared to other energy systems, including other renewable energy technologies. Major challenges to the widespread deployment of USSE installations remain in technology, research, and policy. Overcoming such challenges, highlighted in the previous sections, will require multidisciplinary approaches, perspectives, and collaborations. This review serves to induce communication across relatively disparate disciplines but intentional and structured coordination will be required to further advance the state of knowledge and maximize the environmental benefits of solar energy systems at the utility-scale.

The negative effects of solar energy systems can be minimized with appropriate measures. First, the site selection must be made carefully before use. Roofs are the best platforms for small buildings, and solar modules are a good alternative to glass coating on the walls of large buildings, such as skyscrapers. In order not to cause visual stress, solar modules should be used as a building material during the construction phase, and they should be applied fully integrated with buildings. EIA analysis should be done specifically for centralized solar systems.

There are various precautions that can be taken to minimize the environmental impact of solar energy systems. Due to the toxic substances used in the modules of solar cells, it is advisable to increase the efficiency of the module and its service life, as well as explore the possibilities of processing.

CONCLUSIONS

In my thesis I researched the existing variations of automated power supply systems of a smart home, the proposed energy saving system of a smart home differs from its counterparts.In this work the decision of scientific problems of increase of energy efficiency of the automated autonomous system of power supply of the smart house with use of RES is stated.

1. The analysis of construction of systems of automatic input of a reserve at the smart home is carried out and the system of automatic switching on of reserve power supply (ABP) is offered.

The analysis showed that in order to ensure reliability, it is advisable to install an ABP device with the inclusion of a sectional switch;

2. The cost of electricity from solar system and wind turbines directly depends on the region, where the installation data is set. The time required for capacity generation depends on these factors;

3. The price offered by the integrated power system of Ukraine for electricity is slightly higher than the price produced by wind turbines, so the price for wind turbines is quite competitive, especially when applying green, three-zone and special tariffs.

4. The cost of electricity generation from DES exceeds the cost of its purchase from the integrated power system during peak hours (with the selected one-rate three-zone time-differentiated tariff for calculations). Under normal conditions, a diesel power plant does not produce electricity, but serves as a backup source in the event of a supply interruption from the United Energy System;

5. As a result of solving the optimization problem, the priority energy flows and annual specific indicators of the reduced costs of operation of the combined autonomous power supply system are determined.

6. Thus, the optimal power supply system for a smart home was a combined power supply system with an iridium control system and redundancy.

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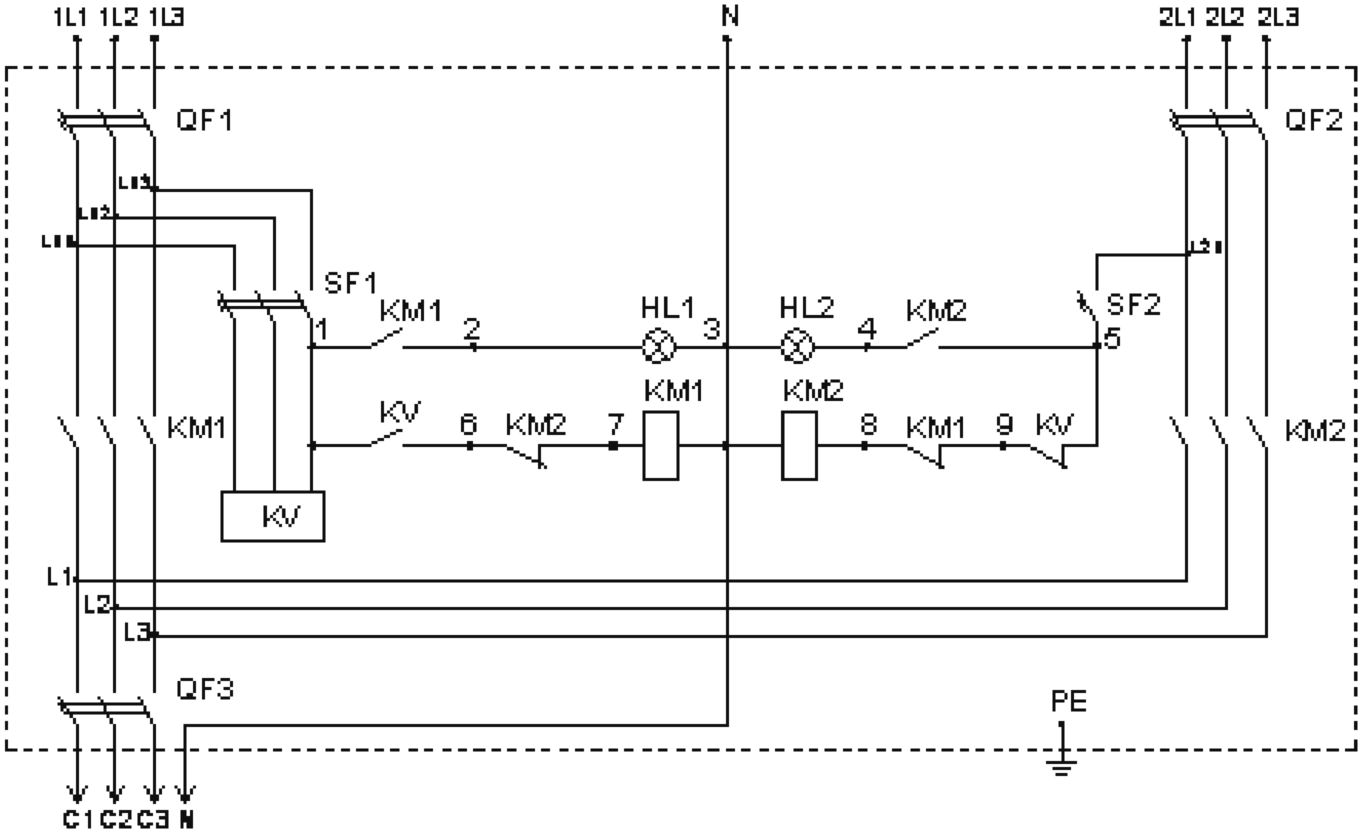
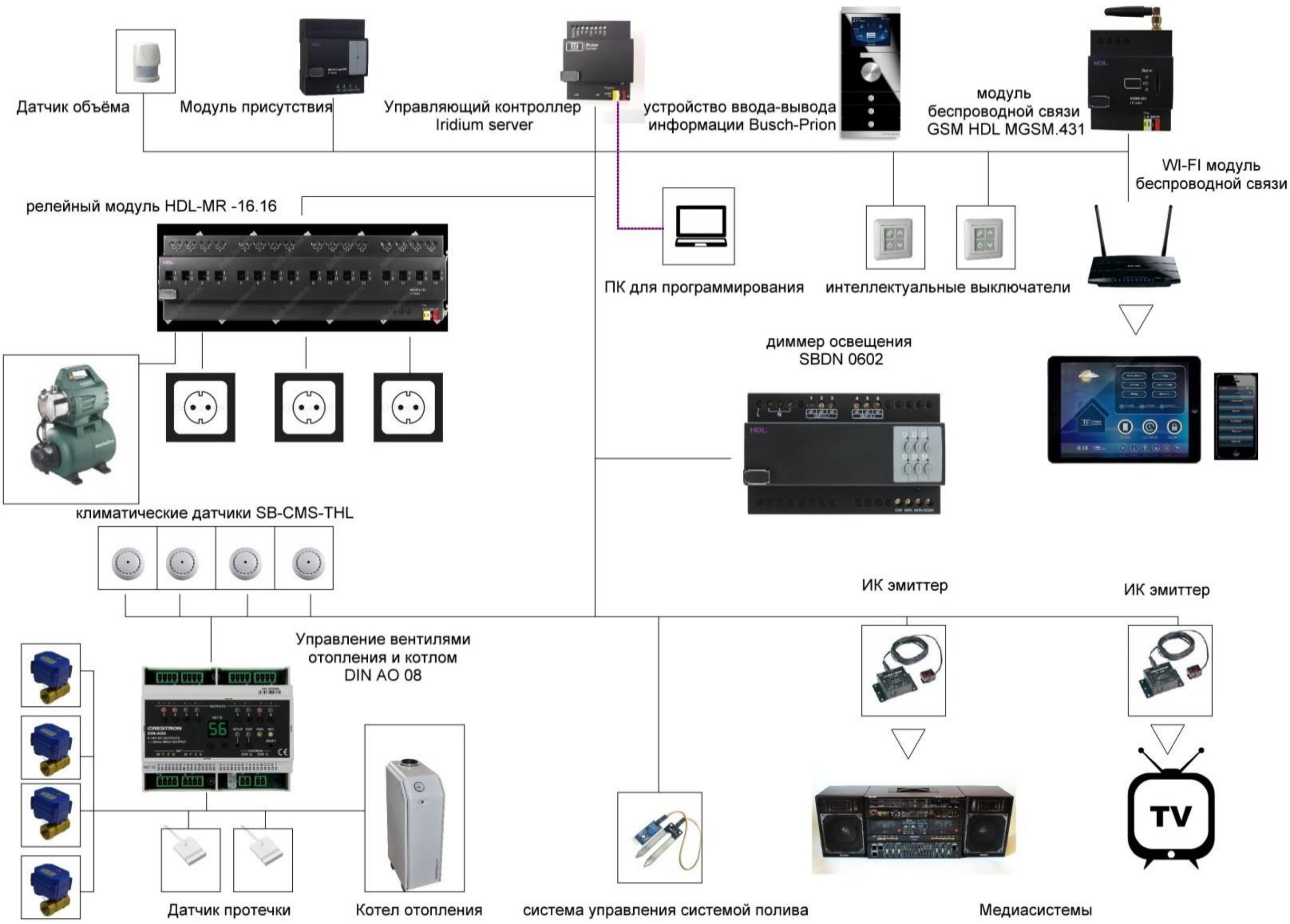
APPENDIX A

Scheme of the input device using AVR



APPENDIX B

Structural diagram of elements according to "Smart House" technology



APPENDIX C

Scheme of the combined power supply system of a smart home.