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

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

QUALIFICATION PAPER

(EXPLANATORY NOTE)

GRADUATE OF EDUCATION AND QUALIFICATION LEVEL
“MASTER”

THEME: CONTROL SYSTEM OF HYBRID POWER PLANT

Executor: **Boiko A.A.**

Supervisor **Ph.D., Associate Professor Vasylenko M.P.**

Advisor on environmental protection: **D.Sc, Professor Frolov V.F.**

Advisor on labor protection: **Ph.D., Associate Professor Konovalova O. V.**

Norms inspector: **Ph.D., Associate Professor Tupitsyn M. F..**

Kyiv 2020

Міністерство освіти і науки україни
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
КАФЕДРА КОМП'ЮТЕРНО-ІНТЕГРОВАНИХ КОМПЛЕКСІВ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
В.М. Синєглазов
"_____" ____________2020 р.

КВАЛІФІКАЦІЙНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬО-КВАЛІФІКАЦІЙНОГО РІВНЯ "МАГІСТР"

Тема: СИСТЕМА КЕРУВАННЯ ГІБРИДНОЮ ЕНЕРГЕТИЧНОЮ УСТАНОВКОЮ

Виконавець: **Бойко А.А.**

Керівник: **к.т.н., доцент, Василенко М. П.**

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Київ 2020

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет аеронавігації, електроніки та телекомунікацій

Кафедра авіаційних комп'ютерно - інтегрованих комплексів

Освітній ступінь магістр

Напрям 15 – Автоматизація та приладобудування

ЗАТВЕРДЖУЮ

Завідувач кафедри

Синєглазов В.М.

" ____ " __________2020 р.

ЗАВДАННЯ
на виконання дипломної роботи студента
Бойко Артема Анатолійовича

1. Тема роботи: «Система керування гібридною енергетичною установкою»

2. Термін виконання роботи: з 01.09.2020р. до 10.12.2020р.

3. Вихідні дані до проекту (роботи): структура гібридної енергетичної установки, математичні моделі компонентів установки, потужність, що генерується установкою, тип та потужність навантаження.

4. Зміст пояснювальної записки (перелік питань, що підлягають розробці):

1. Аналіз проблематики та актуальності. 2. Дослідження екологічного стану навколишнього середовища. 3. Дослідження вже винайдених систем керування гібридною енергетичною установкою та висвітлення їх недоліків та переваг. 4. Вплив на ефективність системи універсального контролера. 5. Висвітлення вже відомих рішень енергоефективних систем. 6. Використання «розумних» технологій для підвищення енергоефективності. 7.Керування за допомогою додатку. 8. Технічні характеристики мікроконтролера. 9. Технічні характеристики системи. 10. Структура розробленої системи. 11. Розробка програмного забезпечення системи.

5. Перелік обов'язкового графічного матеріалу: 1. Актуальність задачі. 2. Аналіз існуючих систем. 3. Дослідження вже винайдених систем керування гібридною енергетичною установкою та висвітлення їх недоліків та переваг. 4. Структура системи. 5. Алгоритм роботи системи.

6. Календарний план-графік

№ п/п	Завдання	Термін виконання	Відмітка про виконання
1	Аналіз актуальності проблеми	01.09.2020-11.09.2020	
2	Дослідження вже існуючих автоматичних систем	11.09.2020-22.09.2020	
3	Розгляд переваг та недоліків вже існуючих систем	22.09.2020-03.10.2020	
4	Розробка структури системи керування гібридної енергетичної установки	03.10.2020-14.10.2020	
5	Формування математичної моделі системи	14.10.2020-25.10.2020	
6	Здійснення вибору програмних засобів для реалізації розробленої системи	25.10.2020-05.11.2020	
7	Реалізація розробленої системи керування	05.11.2020-16.11.2020	
8	Розробка алгоритму роботи системи	16.11.2020-27.11.2020	
9	Аналіз роботи системи, виявлення недоліків та їх усунення	27.11.2020-10.12.2020	

7. Консультанти зі спеціальних розділів

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

8. Дата видачі завдання ______________________________

Керівник: доцент ____________________ Василенко М.П.
(підпис)

Завдання прийняв до виконання ____________________ Бойко А.А.
(підпис)

NATIONAL AVIATION UNIVERSITY

Faculty of aeronavigation, electronics and telecommunications

Department of Aviation Computer Integrated Complexes

Educational level master

Field of study: 15 “Automation and Instrumentation"

APPROVED BY

Head of department

Victor M. Sineglazov

“_____”___________ 2020

Graduate Student’s Diploma Thesis Assignment

Student’s name: Artem Boiko

1. The thesis title: Control system of hybrid power plant.

2.The thesis to be completed between: from 01.09.2020 to 10.12.2020

3. Output data for the thesis: structure of hybrid powerplant, mathematical models of powerplant componrnts, amount of power gnerated by the powerplant, type and power consumption of load.

4. The content of the explanatory note (the list of problems to be considered): 1. Analysis of issues and relevance. 2. Study of the ecological state of the environment. 3. Research of already invented hybrid power plant control systems and identification of their disadvantages and advantages. 4. Influence of the universal controller system efficiency. 5. Coverage of already known solutions for energy efficient systems. 6. Using smart technologies to improve energy efficiency. 7. Application management. 8. Technical characteristics of the microcontroller. 9. Technical characteristics of the system. 10. The structure of the developed system. 11. Development of system software.

5. List of required graphics: 1. Relevance of the task. 2. Analysis of existing systems. 3. Analysis of existing control systems for hybrid power plants. 4. Structure of the system. 5. Algorithm of system operation

6. Planned schedule:

№	Task	Execution term	Execution mark
1	Analysis of the urgency of the problem	01.09.2020-11.09.2020	
2	Research of already existing automatic systems	11.09.2020-22.09.2020	
3	Consideration of the advantages and disadvantages of existing systems	22.09.2020-03.10.2020	
4	Development of the control system of a hybrid power plant	03.10.2020-14.10.2020	
5	Formation of a mathematical model of the system	14.10.2020-25.10.2020	
6	Implementation of the choice of software for the implementation of the developed system	25.10.2020-05.11.2020	
7	Implementation of the developed control system	05.11.2020-16.11.2020	
8	Development of system algorithm	16.11.2020-27.11.2020	
9	Analysis of the system, detection of shortcomings and their elimination	27.11.2020-10.12.2020	

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	D.Sc, Associate Professor, Frolov V.F.		

8. Date of task receiving: ____

Diploma thesis supervisor _______________ Mykola P. Vasylenko
(signature)

Issued task accepted _________________ Artem A. Boiko
(signature)

РЕФЕРАТ

Пояснювальна записка до дипломної роботи «Система керування гібридною енергетичною установкою»: 97 с., 24 рис., 4 табл., 45 літературних джерела.

Об'єкт дослідження: система керування гібридною енергетичною установкою.

Мета роботи: розробка системи управління гібридною електростанцією та підвищення ефективності захисту від ураганів та інших несприятливих природних явищ

Методи дослідження: проведення практичних експериментів, порівняльний аналіз, обробка літературних джерел.

Ключові слова: гібридна система;сонячна панель;контроллер; вітрогенератор; ротор; лопаті; Java; Spring; Git;Java;Database;Maven.

ABSTRACT

Explanatory note to the thesis "Hybrid power plant control system": 97 p., 24 figures, 4 table, 45 literary resources.

The object of research: hybrid power plant control system.

The purpose of the work: development of control system hybrid power plant and to improve the efficiency of protect it from the hurricanes and other adverse natural phenomena.

Methods of research: practical experiments, comparative analysis, processing of literary resources.

Key words: hybrid system, solar panel, controller; wind generator; rotor; shovels; Java; Spring; Git; Java; Database; Maven.

CONTENT

List of abbreviations

1. RE – renewable energy;
2. WPP – wind power plants;
3. SPP – solar power plants;
4. DPP – diesel power plants;
5. HPP – heat power plants;
6. WPI – wind power installation;
7. OOP – object-oriented programming;
8. JVM – java virtual machine;
9. DI – dependency injection;
10. IoC – inversion of control;
11. MVC – model-view-controller;
12. CRUD – create,read,update,delete;
13. POM – project object model;
14. UI – user interface;
15. DB – database;

INTRODUCTION

Modern industry is characterized by a high energy demand. Raw materials, namely, fuel carbons became the main sources of energy, and therefore the most important link in the industry. These circumstances explain the growing exploitation of oil and gas fields.

World stocks of both oil and natural gas are rather ambiguous. Experts' estimates differ from each other, while very significant. This is mainly due to the fact that stocks in many countries are not confirmed and often are underestimated, or extraction in unprofitable fields becomes possible due to technological progress. The stock valuation is carried out to predict global production, and hence prices for the most important energy resources.

Published British Petroleum statistical survey on world energy reserves suggests that the planet has enough "confirmed" oil reserves to provide the world for 40 years, with today's consumption level.

A person using renewable energy needs technologies that use natural phenomena such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological production of hydrogen and geothermal heat. Thus, hybrid power plants are very popular for energy. Therefore, this work is relevant today.

In order to improve the operation of the hybrid power plant, a hybrid power plant management system is proposed.

A basic controller architecture has been developed that collects data from all system sensors and integrates with the application. With the help of the program we will be able to control our system. Thus, it improves the work of our system, makes it more efficient and easy to use, which primarily emphasizes the relevance of this work.

CHAPTER 1. Analysis of the state of energetics

1.1 Modern problems of electric power industry

Renewable energy sources are those power sources that are not decontaminated when using energy. A person using renewable energy sources requires technologies that use natural phenomena such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological production of hydrogen and geothermal heat. Among the aforementioned sources of power there were many energy utilization technologies.

Modern electricity generation is accompanied by pollution, the scale of which in the future may become threatening the environment.

Electricity produced by a hydroelectric power plant (HPP) is cheaper than electricity generated by other types of power plants. But the construction of hydroelectric power stations on plain rivers leads to the flooding of large areas. Much of the area of the formed ponds is the shallow water where algae are actively developing, the so-called "flowering" of water occurs. Changing the water level leads to a complete drying of the soil and leads to the death of vegetation.

In the near future, electric power will be produced mainly by thermal power plants (TPPs). Now they produce over 80% of energy. The advantages of TPPs are that they can be placed in any territory, they work on virtually all types

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Performed	A.A. Boiko	CONTROL SYSTEM OF HYBRID POWER PLANT	N.	Page	Pages
Supervisor	M.P. Vasylenko				
Consultant			205 151		
S. controller	M.F. Tupitsyn				
Dep. head	V.M.Sineglazov				

of mineral fuel and produce not only electric energy, but also internal (hot water for heating and water supply, steam for technical needs). Such a complex production of electric and internal energy contributes to an increase in the coefficient of energy use of fuel to 60-70%.

Further development of heat power is constrained by the fact that TPP is one of the main pollutants of the environment by combustion products.

Even when burning natural gas that does not contain harmful impurities, the products of combustion are nitrogen oxide, which in the atmosphere turns into harmful nitrogen dioxide. Modern condensate type thermal power plants are equipped with very high pipes - 250 ... 300 m for dissipation of harmful impurities in the atmosphere. Wet scrubbers and electronical filters are used to capture ashes. To prevent the release of sulfur compounds, the fuel is pre-cleaned from it, its gasification, as well as the purification of flue gases from sulfur oxides.

Turbines TPP and water vapor, worked out in a steam turbine, must be cooled with running water. Therefore, it is necessary to build the thermal power plant near the large reservoirs.

Until serious accidents at the nuclear power plant (NPP), primarily in the Chernobyl Nuclear Power Plant in 1986, which caused radioactive contamination of a large part of the territory of Ukraine, nuclear power engineering developed at a rapid pace, and in Ukraine, one after another, were constructed nuclear power plants. The analysis of the accident at the NPP showed that the security measures that were used earlier were inadequate and should be strengthened.

The radioactivity of the fuel used and the products of its separation is a serious shortage of nuclear energy. It is necessary to create protection against different types of radioactive radiation, which greatly increases the cost of energy produced by nuclear power plants. The disadvantage of the NPP is also the thermal pollution of water.

The efficiency of the nuclear power plants is about 30%, which is much lower than the efficiency of the TPP.

The increase in the consumption of electric energy, the exacerbation of environmental problems has considerably intensified the search for cleaner methods of obtaining electric energy. Worldwide, research is under way on the implementation of an adjustable thermonuclear reaction, direct transformation of the internal and chemical energy into a non-electric machine. Are developing ways to use renewable energy - solar, wind, geothermal, energy waves, tides and tides, etc.

1.2 The need to use wind energy

Modern industry is characterized by a high energy demand. Raw materials, namely, fuel carbons became the main sources of energy, and therefore the most important link in the industry. These circumstances explain the growing exploitation of oil and gas fields.

World stocks of both oil and natural gas are rather ambiguous. Experts' estimates differ from each other, while very significant. This is mainly due to the fact that stocks in many countries are not confirmed and often are underestimated, or extraction in unprofitable fields becomes possible due to technological progress. The stock valuation is carried out to predict global production, and hence prices for the most important energy resources.

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Stocks of natural gas in Siberia, Alaska and the Middle East should be 20 years longer than global oil reserves. But although natural gas is cleaner than oil, it is the same organic fuel that pollutes the atmosphere. Extremely expensive is its production and transportation in liquefied form.

It is estimated that there are 909 billion tons of explored coal reserves in the world, which will last for at least 155 years. But coal is an organic fuel and a "dirty" energy source, which only worsens the global warming situation.

Fears about the fact that uranium reserves in the world are coming to an end are not justified, since advanced reactors have appeared, and it is also possible to use thorium as a nuclear fuel. However, the growth in the number of reactors around the world increases the likelihood of a disaster, as well as the chances that a dangerous substance will fall into the hands of terrorists.

Information on fuel economy of various types of non-traditional and renewable energy sources is presented in Table. 1.1. On similar principles, the regulation of processes associated with the use of fuel and energy resources in the developed countries during the years of oil crises in the 70's. It should be noted that similar programs in the US and Western Europe stimulated the rapid development of renewable energy sources.

Table 1.1 Information on fuel economy by various kinds of non-traditional and renewable energy sources (in %)

The direction of energy	2000 year	2005 year	2010 year
Wind power	0,018	0,25	0,969
Solar power	0,033	0,111	0,306
Geothermal energy	0,2	2,0	6,4
Small hydropower	0,068	1,533	3,007
Unconventional fuel	1,72	6,5	20,03
Energy of the environment	0,194	0,828	1,257
Small heat power	-	3,95	7,9
Combined power systems	0,002	0,041	0,263
Total	**2,235**	**15,213**	**40,13**

From table 1.1 it is clear that wind power is one of the priority directions of the development of renewable energy sources.

1.3 The need to use sun energy

One of the most promising is the direct conversion of solar radiation into electricity in semiconductor solar cells. The method of direct conversion of solar radiation into electricity is, firstly, the most convenient for the consumer, because it produces the most used type of energy, and secondly, this method is considered environmentally friendly means of obtaining electricity unlike others that use fossil fuels, nuclear raw materials or hydro resources.

For the last five to seven years, solar technologies have shown a unique growth rate of installed capacity for the energy sector - at 30-40% per year. According to this indicator, solar energy is confidently ahead of all other energy technologies. Such high rates of development are defined by considerable decrease in cost of the basic technological equipment of solar power plants.

The use of solar panels in communications, transport, everyday life, agriculture is justified not so much by the amount of electricity they produce, but by the emergence of new opportunities, improving the quality of processes already in use. The effect of the use of solar panels in these areas and industries increases if you use more economical energy consumers, specially designed to work with photovoltaic modules (lighting lamps, refrigerators, pumps, TVs).

In addition, the service life of solar cells is almost unlimited and can be decades. In developed countries, strong investments are being made in new scientific developments, the main purpose of which is to reduce the cost of solar energy, and to form new markets for consumption.

Suffice it to mention the program "Million solar roofs" in the US, "100 thousand solar roofs" in Germany and Italy and others. The governments of the United States, Japan, and Western Europe encourage solar energy consumption by the population, primarily because it is environmentally friendly and saves limited resources of fossil fuels.

1.4 Hybrid power systems

Hybrid solar power plants are combined backup power systems, in which, besides solar panels, other sources can be used to provide electricity: centralized electricity grids, wind turbines, gasoline or diesel electric units (Fig. 1).

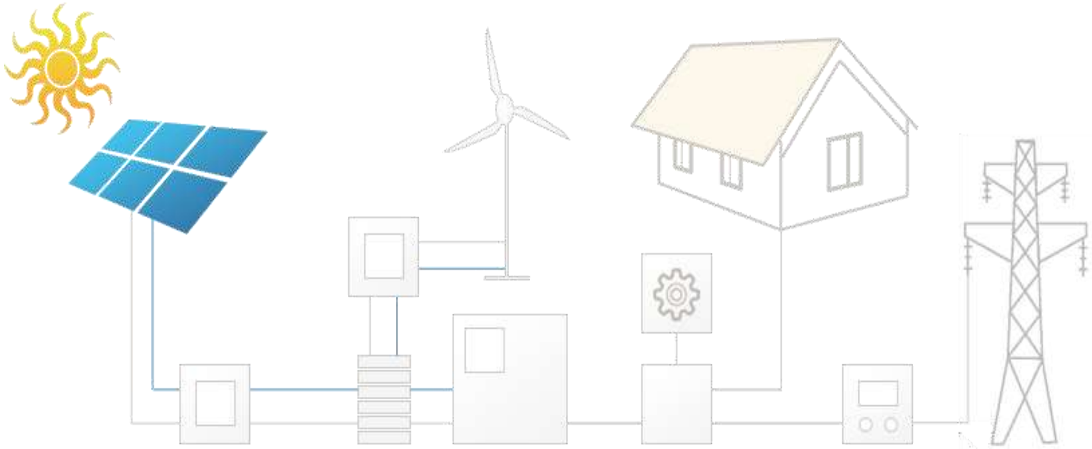


Fig. 1 – Kinds hybrid power system

Hybrid energy systems usually combine many renewable sources of energy: solar panels, mini-hydropower stations, wind farms (WPPs) and other energy storage devices, designed primarily to provide electricity, heat sources (biogas plants) (diesel generators), which serve as a backup source of energy.

The technological changes in the electrical networks can be classified according to the type of voltage in the grid: direct, alternating current or mixed lines.

In hybrid AC systems, the main voltage sources can be connected directly to the AC line or by additional converters to provide the required AC characteristics when connected to a central power supply system. The power supply to charge the batteries directs the inverter in both directions, as well as the batteries to AC power. DC power can be supplied with battery voltage.

Hybrid systems are divided into sequential, variable and parallel. In successive systems, the batteries are charged by a solar photovoltaic unit or by a dc diesel generator without the solar radiation.

AC power loads are powered by a battery converter. The system can be operated manually or automatically in the presence of battery chargers and a diesel generator controller.

System downsets - frequent recharging of the battery, reducing its lifetime, the need for high capacity batteries (to reduce the depth of discharge). The failure of the inverter leads to complete disconnection of consumers from the grid.

In switching hybrid systems, AC voltage for consumers can be powered by a battery-powered, renewable or generator converter. Batteries are charged from renewable sources or from an oil generator via a rectifier.

If the system is in automatic mode, the controllers create the necessary configuration of the system, which provides uninterrupted power to consumers and the required battery charge level.

Hybrid switching system compared to a steadily more reliable source of energy, but also more complex.

In the parallel configuration of the hybrid system, it is possible to supply power to consumers regardless of each source entering the system and at the same time from all peak loads when it is necessary to synchronize the voltage form at the output of the inverter and the generator. The load of the transformer substation consists of the consumer load and the generation of electricity sources found in their balance sheet.

The hybrid system consists mainly of three elements:

1) Distributed power generation system.

2) Intelligent control system.

3) Cordless system.

These systems have the advantage of ensuring the stability of the supply of electricity through the combination of different technologies, thereby offsetting the negative side when using the same technologies separately (for example, high fuel cost when using only a generator unit or the impossibility of using the solar panel at night), and on the other side - lower operating costs with a corresponding increase in system efficiency.

The sharp increase in the world's energy resources and the continued depletion of hydrocarbons will lead to a long-term constraint in economic development around the world.

Hybrid systems based on RE are independent of oil prices. Even if these systems include a diesel generator as a backup, however, RE will provide 60 to 90% of the energy consumption. While the practice of submitting claims to electricity quality is lacking, there are no compensation mechanisms for poor quality.

Much of the low-power power plants (and they prevail in our country) are excluded from regulation within the framework of a unified energy system. Only the expansion of the management of distributed generation will enable the inclusion of small power in a single regulatory system.

The operation of the power system with a small number of energy sources could be built up by analogy with the fact that the source was only one, there were no counter flows in such a system.

But the increase in the number of sources, the reduction of the share of stable electricity among them, leads to the fact that electricity has to be transferred promptly, in different directions, that is to a distributed and dynamically changing generation, to which the electric networks of Ukraine are not ready. And this is due not only to the complexity of managing a system with a large number of power plants.

When managing a distributed generation power system, there will be more opportunities to reduce electricity losses during transportation. At the expense of reduction of the losses occurring at frequency and voltage fluctuations, it is possible to save at least 2.1% of electricity.

Future upgrading of electric networks on the way to hybrid networks is not limited to overall energy savings, it allows you to save it where it really is necessary, maximally bring savings to consumers. Automatic devices increase bandwidth and network stability, which is especially important for highly loaded power systems, eliminating the need for investment in the construction of new power lines, which will lead to significant cost savings.

In the normative base of many countries regarding the connection of distributed generation to the grid system (grid code) there are the following requirements:

- maintenance of tension on bus stations;

- requirements for stability in transient processes during short circuits;

- active power regulation; - requirements for the quality of electric energy; - Requirements for the influence of wind power plants (WPP) and solar power plants (SPP) on the stability and reliability of the functioning of the power system, the quality of regulation of the electrical parameters at the point of their connection, the level of short-circuit currents;

- Requirements for main equipment and to regulate WPP and SPP systems under conditions of parallel operation with the grid.

The world-wide experience of using renewable energy sources (RE) shows that energy generation by wind farms, solar panels and water heaters is heavily dependent on the season and weather conditions, which causes problems with the stability of energy supply. This task is solved by using such types of RE in the existing energy networks or as an additional source of energy. However, in recent years, a sufficiently large number of developments have been proposed that provide sustainable energy supply to facilities through the use of so-called hybrid power systems based on RE. Hybrid power systems often combine several renewable energy sources: solar panels, mini-HPPs and other energy storage devices, which are primarily intended to provide electrical energy. The system may also include heat sources (biogas plants, solar thermal collectors) and sources of organic fuel (diesel generators) that serve as a backup power supply. Technological changes can be classified according to the type of voltage in the network: constant, alternating current or mixed lines.

An important role in providing power supply to the national economy belongs to intellectual networks, and their significance will be steadily and rapidly growing. Technological platform consists of various modern means, such as devices and technologies based on power electronics, superconductivity, electromechanical evaporator complexes. The intelligent power system should include elements and subsystems that maintain an appropriate level of electrical energy and electromagnetic compatibility, provide the necessary level of reliability and uninterrupted power supply, including the possibility of using alternative renewable energy sources, maintain an appropriate level of stability of the power supply system with the ability to operatively control the configuration of the electrical network, by automatic sectioning to provide optimal the voltage specified criteria, perform complex automated control of energy consumption, energy efficiency and energy consumption during exercise structuring consumers the opportunity to situational stress management in terms of interaction between control centers.

A relatively new approach to ensuring the reliability of the grid is the inclusion of so-called distributed energy resources in it. These include cogeneration of heat and electricity and alternative energy sources. Connecting to a local area network of renewable energy sources can protect consumers from accidental interruptions in power supply. Therefore, the growing demand for high-quality electricity supply for enterprises in the continuous production cycle and information and communication companies offers great opportunities for small electricity producers based on the use of local, mostly renewable energy sources. Taking into account the analysis of the problems faced by hybrid energy towards the development of smart grids, one can formulate the basic technical requirements for autonomous power supply systems that will be implemented in the power supply system:

1) multifunctionality and combination of sources of energy (hybrid power plants);

2) modular layout on the basis of typing and constructive unification and the possibility of autonomous operation of power modules;

3) the coherence of the characteristics of power modules: diesel, generator and consumer loads;

4) the possibility of joint operation of the diesel power plant (DPP) with non-traditional energy sources (hybrid power plant), as well as with the power grid;

5) ensuring the high quality of electric and thermal energy, regardless of the load fluctuations and the potential of renewable energy;

6) reliability, resource and efficiency of functioning of hybrid and stand-alone stations;

7) maintenance of safety and convenience of the operator of the DPP, typing and unification of the DPP park, power equipment and components, fuel and motor oils and fuel efficiency;

8) adaptability to climatic (zonal) conditions and protection of the environment when using power equipment;

9) high level of automation and dispatching under conditions of development of smart grid;

10) low operating costs and ease of carrying out preventive measures;

11) technological and cheap production, use of the extended nomenclature of nodes and their interchangeability on the basis of local enterprises.

In connection with the development of intellectual networks, consumers are expanding with choosing ways to save energy costs. Any firm can create its own source of electricity, in particular, renewable, if it would be advantageous and easily sell it to the network. Now on the way of such a new seller there is an obstacle created by the monopolist. And this obstacle is partially justified: the existing network is not able to accept irregular supply of electricity from a new source.

Among the advantages of receiving a hybrid SPP:

- protection from short-term, fan trips;

- the possibility of selling electricity;

- "selection" of energy from the network when it is lacking;

- minimization of the use of traditional electricity, reduction of electricity bills.

Hybrid solar power plants allow you to take advantage of a household electrical grid, sell electricity to the Grid based on the Green Tariff, and provide complete energy independence in case of disconnection of the domestic network.

This is a combination of installations that allow you to recharge batteries and provide autonomy, as well as to provide surplus electricity to the network for sale at the Green Tariff. These stations combine the properties of a network and autonomous solar power plant and are naturally more expensive. The hybrid station is designed for households whose owners want to reduce the risks of electricity interruptions, to profit from the sale of surplus electricity generated by solar panels. The cost to the hybrid station is higher than the standalone and even more network. With the advent of intelligent electric networks with a new measurement system, the positions of energy market participants will change dramatically. This also involves difficulties in the way of their implementation. Purely technical barriers are due to the backwardness of domestic networks, the lack of normal technical documentation, regular repairs, etc.

At the same time, an increase in the share of renewable energy in total electricity production can create a number of systemic problems. They are related to the influence of fluctuations of wind and solar energy generation schedules on the power system operating modes, especially at low load levels, as well as the lack of technical means for maximum accurate meteorological forecasting, which would allow system operators to optimize the influence of weather conditions on generation and load schedules. If the share of wind energy in electricity generation reaches 15-20% of the installed capacity of the system, then fluctuations in the power of wind power plants can adversely affect the dynamic stability of power systems.

In order to reduce this negative effect, it is necessary to have a power reserve in the power system at traditional power plants, comparable to the total power of wind power plants. Traditional power plants should be able to quickly gain power.

Regarding the dynamical characteristics of a power system with a high penetration rate of agriculture, in which solar power plants (SPP) are connected directly to main transmission lines, the so-called zero inertia of the solar generation is the biggest problem. Several successful voltage inverting technologies have been developed and implemented, but this remains a serious technical barrier to the integration of large SPP into the grid. There is a problem of voltage stability and regulation of the SPP after voltage drop.

Additional technical measures aimed at maintaining the quality of energy supply in mixed power generation systems at the required level can significantly increase the primary cost of implementing a wind or solar project and reduce its overall commercial efficiency.

Potential reduction of energy efficiency of the entire grid can lead to significant negative environmental effects. Therefore, the technical and economic aspects of the integration of SPP and WPP into a single grid must be taken into account at the stage of designing and selecting the place for the construction of the wind and solar power plant.

Electric power storage is an essential element of future intelligent power systems and creates significant effects by using the principle of energy accumulation during its excess production and energy delivery during its shortage.

It is necessary to overcome the technological problems that currently make the use of energy storage devices economically unjustified.

The widespread introduction of hybrid systems will largely depend on the release of domestic affordable equipment (wind power plants of low power, solar panels and water heaters, heat pumps, etc.).

In connection with the plans adopted in our country for the construction of wind parks should not be discounted from the accounts and capabilities of hybrid systems for large energy in terms of solving the problems of peak loads, accumulation of surplus electricity, rational use.

Hence, the use of renewable energy based hybrid systems is a promising solution for decentralized electricity supply in rural areas and remote sites, to ensure the accumulation of surplus electricity, the removal of peak loads during operation, and the reduction of dependence on seasonal and weather conditions from the use of renewable energy sources great power

For Ukraine, due to the lack of coal for the (heat power plant) HPP plant and the long-term agricultural development program, hybrid technologies should be considered as an alternative to centralized electricity supply with the further development of compensation mechanisms for low-quality electricity on the way to the development of smart grids.

The introduction of generating renewable energy sources with a conversion frequency based on power electronics will allow the production of "green" energy and at the same time provide flexible control of the modes of the adjacent networks, increase of reliability of power systems and quality of electricity supply to consumers.

Conclusion: this chapter provides an overview of the existing types of wind and solar installations, as well as methods for their protection from adverse weather conditions.

CHAPTER 2. Analyses of concept a wind-solar hybrid system

2.1 Overview the wind-solar hybrid plant

Solar and wind energy are non-exhaustible, site-dependent, non-polluting and potential alternative energy sources. The use of solar and wind energy has become more and more significant attractive and profitable. However, the common disadvantage of solar and wind energy is their unpredictable nature.

Stand-alone photovoltaic (PV) or wind energy systems do not produce usable energy for much of the year. This is mainly due to the dependency on sunshine hours, which are variable in the first case, and relatively high start-up wind speeds, ranging from 3.5 to 4.5 m/s, in the second case, resulting in underutilized capacity. In general, variations in solar and wind energy do not correspond to the temporal distribution of demand. The independent use of the two systems leads to a considerable oversizing of the system reliability, which makes the design expensive.

The initial cost of a solar or wind power system is higher than that of a diesel generator of comparable size, but the operating and maintenance costs are always lower than those of the diesel generator. As the benefits of solar and wind energy systems are widely known, system designers have begun to investigate their integration.

The term "Renewable Energy Hybrid System" (RHIS) is used to describe any energy system with several types of generators: typically a conventional diesel-powered generator, and a renewable energy source such as photovoltaic, wind andphotovoltaic/wind. For remote areas, HRES is often the most cost-effective and reliable way to produce energy. However, solar and wind power in a HRES can reduce fluctuations in output, reducing significantly energy storage requirements.

Fig.2.1 - Wind-solar hybrid plant

Over the past decade, HRES has become a viable alternative for energy production as it allows designers to capitalise on the strengths of conventional and renewable energy sources. HRES invariably includes the storage of batteries to meet demand when demand is at peak or when the renewable energy source is not available. Battery storage also helps to smooth the time interval between the onset of peak load and maximum output power.

The concept of HRES depends mainly on the performance of an individual system. In order to predict performance, individual components should be created first and then their combination can be assessed to reliably meet demand. If the output power forecast of these individual components is sufficiently precise to ensure that the resulting combination provides energy at the lowest cost. This approach is being adopted by researchers. The aim of this paper is to examine the current state of HESR modelling, particularly with regard to solar and wind energy.

The methodologies generally adopted for modelling the system components are described. A review of the work reported by several authors follows. The paper also discusses the need to consider future needs in designing HESRs. Hybrid power plants that combine solar and wind energy can have a many advantages over clean wind or solar power plants.

From a social point of view PPH can reduce the cost of infrastructure investments, as in most cases it's necessary to create a single point of connection to the network .

This reduces the overall cost of network investments and associated fees for network. Secondly, land is used more efficiently by increasing installed capacity and energy production per square meter of land used.

Based on these facts and the potentially better use of plant resources, CHPs may have lower electricity costs and therefore need less economic support to be profitable. In fact, developers are exploring synergies in the develop and licensing process, using only one network connection, using the site more efficiently and implementing common management and maintenance strategies.

In terms of system integration, given the gradual shift away from traditional power plants, cogeneration plants can offer a more reliable alternative to power with a high flexibility potential compared to wind or solar power plants. This is the case when the wind and solar profiles on the site have a negative correlation (they must complement the daytime periods, which is often the case) in order to avoid ramp-up problems and time peaks.

Due to the coexistence of production units and digital technologies of different capacities, PPH is a good network partner not only in terms of flexibility, but also in terms of storage resistance. The latter can lead to lower balancing costs and reduced use of renewable energy sources , both of which are socially beneficial.

From a developer's perspective, hybridization of an existing wind farm could maximize total network capacity. In most cases, the inverter that connects the RES power plant to the grid is large to achieve the worst case scenario. However, the latter scenario may occur in less than 5.5% of the implementation time.

Under certain conditions it makes sense to control the use of the inverter capacity using existing technologies and connect more RES to the inverter. In this way it is possible to optimize the size of HPP. Although such a project may lead to less energy leakage, it certainly plays a role in creating a viable hybrid wind farm.

2.2 The main components hybrid system

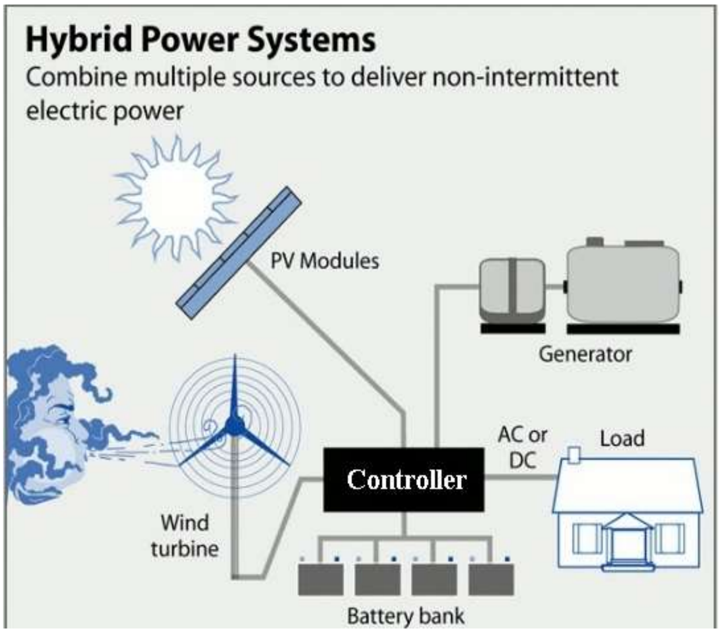


Fig.2.2 – Hybrid power plant include the main components are: 1) PV modules; 2) Wind turbine; 3) Controller; 4) Generator; 5) Battery bank; 6) Load system.

There are different types of solar-wind hybrid systems in the world. The choice of this system depends on many factors, such as: climatic zone, weather conditions, altitude, relief and many other factors. This thesis will provide a universal setting. Fig. 2.2 shows the main components of a hybrid system.

In this table you can see the main technical characteristics of the hybrid system.

Components HPP

Fig.2.3 – Photovoltaic system

Three types of silicone PV modules are included for testing PVC (monocrystalline, polycrystalline and amorphous triple seals), but our system use only one type of PV module.

The power of a PV panel is not the same for all PVWHs, for two reasons: first, the load is not the same size and second, the power of each ot the same for all business modules.

PV panel control at PVWH levels from 150W for villas type B to 320W for the dining room. Modules in photovoltaic panels added to the equation.

For optimal performance, the goal of land-based PV systems is to extend the duration of exposure to the sun. Solar monitors achieve this by moving the

PV modules behind the sun. The increase can be as high as 20% in winter and 50% in summer.

Most traditional systems can be improved by analyzing the operation of the sun. Parts of the PV panels are usually placed at an angle corresponding to the width, but the work can be improved by setting the summer or winter angle. In general, temperatures above room temperature, like other semiconductor devices, reduce the performance of the modules.

Its main components are high voltage modules, batteries and converters. The most effective way to determine the capacity of these components is to estimate the payload. The required battery pack depends on the desired storage location, maximum discharge rate, and lowest temperature at which the battery is located.

When designing a solar power system, it is important to consider all these factors when determining the size of the battery. Lead-acid batteries are the most common batteries in power systems because their initial costs are low and are almost available worldwide. Deep-discharge batteries are designed to consume up to 80 percent of their recurring capacity, making them a good energy choice.

The 1000 W option is an example and can be applied to any desired power. To get 1000 watts of solar power, you will need to use a solar panel, a charge controller and a battery and the inverter is identified.

The price cannot be chosen randomly, hence the measurement and its dimensions they must be arithmetically implemented in another system so that the system can operate according to the required parameters. This is a structure working time was estimated at 12 hours and calculated as follows:

PV module power = 1000W;

Period of operation or duration = 12 Hours

The period of the solar panel exposed to the sun = 8 Hours (Averagely between 9am and 3pm)

If solar panel of 100W is to be use the number of panels

This shows 10 of 100 Watt solar panel will be required for this design.

Fig.2.4 – Wind turbine

A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy. Wind turbines can be separated into two basic types based on the axis about which the turbine rotates. Turbines that rotate around a

horizontal axis are more common.

Vertical-axis turbines are less frequently used wind turbines can also be classified by the location in which they are used as Onshore, Offshore, and aerial wind turbines.

The blades of wind turbines turn under the effect of the wind. Also, the wind does not have to be strong.

Most turbines have blades with wind or moderate speeds of 3-7 meters per second. This trick turns the shaft into a race-like model on top of a ventilated turbine.

The generator attached to the bicycle converts the kinetic energy of the shaft into electricity.

The block diagram in Fig. 2.5 shows the conversion process of wind energy to electrical energy.

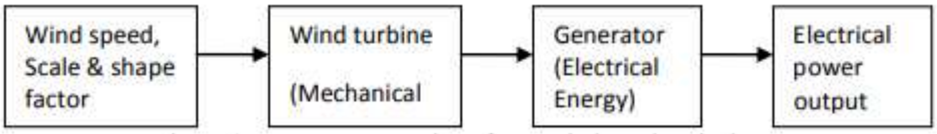


Fig.2.5 - Energy conversions from Wind to Electrical

Various mathematical models have been developed to estimate the performance of wind turbines.

A statistical operation, known as a vibration distribution operation, has proven to be more suitable for this purpose. This function is used to determine the air distribution at the selected site of the study and the average / monthly wind speed at the site.

Vibulous distribution has been proposed as a more common model for this purpose. The variance distribution of the two variables is represented by equation (2.1) in mathematics.

$$F(v) = \frac{K}{C}\left(\frac{v}{C}\right)^{K-1} \exp\left[-\left(\frac{v}{C}\right)^{K}\right]. \qquad (2.1)$$

It has a cumulative distribution function as expressed in equation (2.2), and is given as:

$$M(v) = 1 - exp\left[-\left(\frac{v}{c}\right)^{K}\right]. \qquad (2.2)$$

Where v is the wind speed, K is the shape parameter and C, the scale parameter of the distribution. The parameters K (dimensionless) and C (m/s) therefore characterized the Wiebull distribution. To determine K and C, the approximations widely accepted are given in equations (2.3) and (2.4).

$$K = \left(\frac{\sigma}{V^1}\right)^{K-1} \quad . \tag{2.3}$$

$$C = \frac{V^1 \times K^{2.6674}}{0.184 + 0.816K^{2.738}} \, . \tag{2.4}$$

where σ = standard deviation of the wind speed for the site (ms-1) V′ = mean speed (ms-1).

Characteristics wind turbine:

Wind turbine power: 500W at 10 m/s

Wind turbine type: 3 blades

Fig.2.6 – The diesel generator

Diesel generators are used to fill the space between the load and the energy produced by the photovoltaic system.

Battery storage can be used to increase overall system efficiency and ensure the power supply is full. It is also possible to integrate a power management system to increase the efficiency of the system due to the limited capacity of the diesel generator and the inconsistent production of solar energy.

Fig.2.7 – The battery banks

Battery energy storage system (BESS) are includes batteries, control system and power electronic devices for conversion between alternating and direct current. The batteries convert electrical energy into chemical energy for storage. Batteries are charged and discharged using DC power, regulates the flow of power between batteries and the energy systems is done by a bi-directional power electronic devices.

Different types of batteries have various advantages and disadvantages in terms of power and energy capabilities, size, weight, and cost. The main types of battery energy storage technologies are: Lead-Acid, Nickel Cadmium, Sodium Sulfur, Nickel Metal Hydride and Lithium-Ion. Lead-Acid batteries, achieve high discharge rates by using deep-cycle batteries.

Components which include the toxic-heaviness of cadmium and higher self-discharge rates than Lead-Acid batteries. Also, NiCd batteries may cost up to ten times more than a Lead-Acid battery, making it a very costly alternative. Nickel Metal Hydride (NiMH) is compact batteries and provides lightweight used in hybrid electric vehicles and tele-communication applications.

According to , NiMH batteries can substitute NiCd batteries in communications. They also provide equivalent cycle life characteristics, are environmentally friendly and can provide for an additional capacity ranging from 25 to 40%. Lithium-Ion technology has the highest energy density amongst all types of batteries . They are currently used in cellular phones, computers, etc. and development of this technology is used in distributed energy storage applications.

Low energy density, non-environment friendly electrolyte and a relatively limited life-cycle are the limiting factors to its dominant use in urban renewable energy systems.

Changes in wind and solar photovoltaic energy the output causes an instantaneous change to a good result.

And the BESS output must neutralize sudden changes in output power. Speed difference control (or speed control) applied to facilitate actual power fluctuations. The system is connected. As a rule, the allowed dialing speed is determined electricity consumption in kVh per minute (kVh), a common characteristic of wind and solar energy.

Agreements between utilities and independent government Manufacturers. The information is processed by the battery. Power System Controller Assess Charge Status (SOC) The capacity of each cell and each cell and protects all cells operating in the developed SOC range.

The amount of electrochemical energy remaining in the battery SOC is measured. SOC information is then used Load leveling control. This is expressed as a percentage of battery capacity.

The response in the batteries is very complex and complex the model is quite reasonable. It's SOC the main differences are explained in the SOC with chemical and electrical properties production, aging and ambient temperature.

When the SOC remains without any control like cell adhesion Energy storage energy is very small. So, compensation it needs to be aligned to reduce the difference Extension and battery life.

Usually SOC Controlled from 30% to 70% over a long life cycle for the battery. Technical and economic advantages small energy storage systems: sample and overall more efficient use energy sources. Improving the reliability and quality of electricity Supply. Providing backup power for critical loads.

Battery capacity:

Operational period = 12 Hours

Battery cell voltage = 12 volts

Number of series connected batteries = 32

Invertor:

Since the total load is 1,5 kW it is advisable to size the required inverter to be 2 kW as designed for solar panel ratings. Hence 2 kW pure sign wave inverter is recommended in other to prolong the lifespan of the inverter.

Charging controller:

For this design of 2 kW solar power supply P=IV

Where I is the expected charging current and

V is the voltage of the battery = 12 V

P is the power supply rating= 1,5 W

Hence I =P / v = 2000 / 12 = 166,6$Amps$.

Since the value 166,6 Amps Charging controllers is not readily available in the market then 2000 A charging controller will be used.

2.3 Wind-solar plant control system

Management strategy plays an important role in the functioning of the system. Proper control system increases power availability, system efficiency, battery life and amount of energy produced.

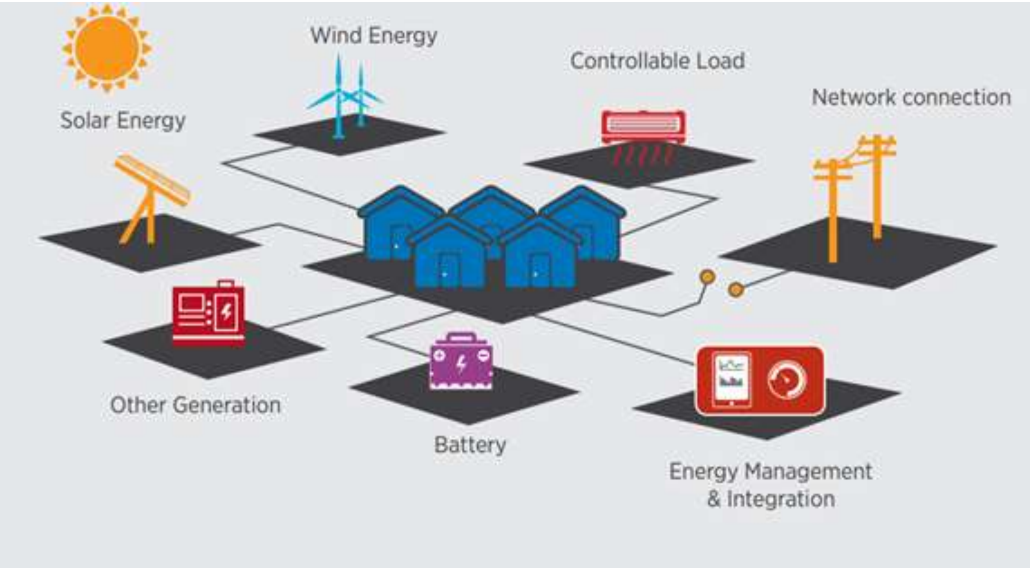


Fig.2.8 – Wind-solar components which are controlled by the control system

It also reduces the number hours of shortage, hours of engine operation and power reduction. Some other problems that should be the control system takes into account battery management, ignition / engine shutdown, the desire for maximum power available solar and wind energy, load management, energy quality in the process of energy production and operation various components.

Conclusion: this chapter provides an overview of the wind-solar hybrid system. All the main components of the system and their technical characteristics were described.

CHAPTER 3. Mathematicals models of each component in the system

3.1 Overview solar panel operation

A photovoltaic module consists of a series of cells that are parallel to the desired output voltage and current level cells to produce the current level. The cell of each cell is a pn diode when the rays of the sun hit a cell, the incident energy is directly converted into electrical energy.

Single-diode mathematic model is applicable to simulate silicon photovoltaic cells, which consists of a photocurrent source I_{ph} , a nonlinear diode, and internal resistances R_s and R_p , as shown in Fig. 3.1.

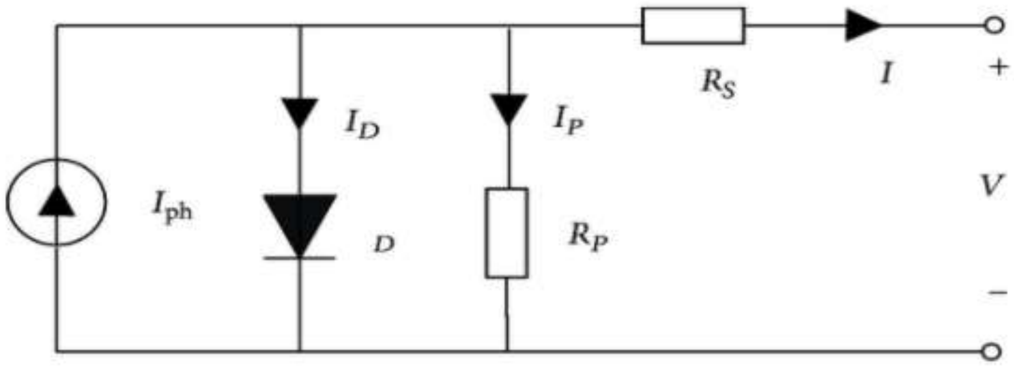


Fig.3.1 – Single-diode mathematical model of a PV cell

The operating temperature of the element, which differs from the ambient temperature, determines the open circuit voltage. The operating element temperature can be calculated using (3.1) formula:

$$T_c = T_a + 0.03 * G_a^2 \qquad (3.1)$$

where T_c is the operating cell temperature, T_a is the ambient temperature in Kelvin, and G_a is the irradiance in W/m^2. Open-circuit voltage of the cell can be calculated using:

$$V^C_{OC} = V^C_{OC,0} + (-2.3\ mV/C) * (T_C - T_0^C) \qquad (3.2)$$

For the PV cell, the short-circuit current is proportional to the irradiance where the open-circuit voltage is a logarithmic function of the current. Using **(**3.3**),** short-circuit current of a PV cell can be calculated for a given irradiance:

$$I^C_{SC} = \frac{I^C_{SC,0}\ G_a}{G_{a,0}} \qquad (3.3)$$

PV module's short-circuit current is proportional to the number of parallel connected PV modules:

$$I^M_{SC} = N_{PC} * I^C_{SC} \qquad (3.4)$$

PV module's open-circuit voltage can be calculated using:

$$V^M_{OC} = N_{SC} * V^C_{OC} \qquad (3.5)$$

The equivalent series resistance of the module can be calculated as:

$$R_S^M = \frac{N_{SC}}{N_{PC}} * R_S^C \quad (3.6)$$

The PV module's current I_M under arbitrary operating condition can be described as:

$$I^M = I_{SC}^M \left[1 - \exp\left(\frac{V^M - V_{OC}^M + R_S^M * 1^M}{N_{SM} V_t^C}\right)\right] \quad (3.7)$$

The necessary number of PV modules to be connected in series is derived by the number of modules needed to match the bus operating voltage as depicted in:

$$V_{PV} = V_{OC}^{MC} * N_{SM} \quad (3.8)$$

The current output of a PV array at time t, I^M (t), is related to the number of parallel strings as:

$$I_{PV}(t) = I^M(t) * N_{PM} * \int MM \quad (3.9)$$

The power output of the PV array at time t is:

$$P_{PV}(t) = I_{PV}(t) * V_{PM}(t) \quad (3.10)$$

3.2 Overview wind turbine operation

The characteristic curves of wind turbines are presented as the dependence of the power output on the wind speed at the height of the axis. Wind turbines are never connected in series. Multiple wind turbines can be connected in parallel to meet current system requirements.

This can be done with parallel chains of the same type of wind turbine or with ropes of another type of wind turbine. It is assumed that no more than two different types of turbines are used in a system at the same time. The annual wind energy density is calculated using:

$$\mathrm{P_{WT}} = 0.5 * \mathrm{C_P} * \ \mathrm{p_{air}} * \ V^3. \qquad (3.11)$$

If we assume the average yearly energy demand as D , we can determine average of the wind turbine diameter D_{WT} using formula (3.11), so that the wind turbine type can be defined easily:

$$\mathrm{D_{WT}} = \sqrt{\frac{D_{av,year}}{\frac{hours}{year} * P_W * \pi * (1/4)}} \ . \qquad (3.12)$$

The power output of the wind turbine array at time t is:

$$\mathrm{P_{WT}(t)} = 0.5 * \mathrm{C_P p_{air}} * \ V^3(t). \qquad (3.13)$$

3.3 Overview battery model operation

The batteries in the hybrid system are routed in series to obtain the appropriate rated bus voltage. Therefore, the number of batteries in series for the same type of battery in the battery is calculated as follows:

$$N_{SBat} = \frac{V_{PV}}{V_{Bat}} \quad . \qquad (3.14)$$

A hybrid system can have several types of batteries. The state of charge of the battery at that moment is calculated by adding the charging current (positive sign) or discharge (negative sign) to the state of charge of the battery at the previous moment. When adding battery current to the battery's state of charge, consider the loss of self-discharge and the loss of battery charge:

$$SOC(t+1) = \sum_{i=0}^{BatBan}\left[SOC_i(t) * \sigma_i + I_{Bat}(t) * \Delta t * n_{(I_{kolbat}(t))}\right] * N_{PBat} \ . \qquad (3.15)$$

3.4 Overview invertor, charger and loads performance

The inverter characteristics can be described by the inverter input and output relationship. Some of the power supplied to the inverter will be lost due to transformation losses that are named inverter efficiency losses, n_{inv}

$$P_{inv-ip} * n_{inv} = P_{inv-op}, \ n_{inv} = \int \left(P_{inv-op}\right) . \qquad (3.16)$$

In fact, charging monitors can be likened to a connecting voltage that disconnects the battery generator or charge based on battery charge, temperature, or charge. The output power of the $P_{BC\text{-}op}$ plate is proportional to the $P_{BC\text{-}ip}$ input capacity multiplied by the loss of efficiency during the power switch. The loss of efficiency is not straightforward with DC power generation and therefore is not straightforward for DC power generation:

$$P_{iBC-ip} * n_{BC} = P_{BC-op,}\ n_{BC} = \int\left(P_{BC-op}\right). \qquad (3.17)$$

Efficiency losses can be calculated from efficiency losses versus output power cuves that are given by the manufacturers. In most cases, two types of loads are present, DC appliances of 12V, 24V, and 48V or AC appliances of 220V. The estimated power consumption should be given in intervals of hours, days, or years. If both a DC and an AC generator exist, some of the DC generators energy can be routed through the inverter to the AC loads:

$$P_{Gdc} \geq I_{dcL,}\ \text{or}\ I_{Gdc} = I_{dcL} + I_{inv-ip}. \qquad (3.18)$$

3.5 Costing model of Hybrid system

The operating costs of a hybrid system are generally non-linear and largely depend on the size and type of body parts and how the system operates. They can only be estimated because they are based on future work.

The sizing variables are sizes of component types and their number is to be installed. From the PV module, wind turbine, battery, battery charger, and inverter performance models sizing variables.

A hybrid system should include operating strategies that describe the flow of energy between the generator and the load. The optimized operating decision variables represent routing and operating decisions based on the power flow modeled for the hybrid system.

The main variables for deciding on the operation of the hybrid system are the minimum battery charge, SOC_{min} , maximum battery charge SOC_{max} , PV charger control switch, CS_{CPV}, CS_{CWT} wind generator charger control switch, CS_{IN} inverter control switch, and CSL load control switch. Some of these decision variables can be set before optimizing the hybrid system.

The hybrid system model has many limitations in terms of technological, socio-economic, legal, or physical aspects. The limitations in the presented approach are set by the technical characteristics of the battery operation and the correspondence between the demand and the produced energy. The restrictions can be formulated as follows:

$$SOC\,(t) \geq SOC_{min,}\ SOC_{min} = 1 - DOD_{max}\ . \qquad (3.19)$$

where $\mathrm{DOD_{max}}$ is the max depth of discharge of the battery. Consider

$$I_{pv}(t) + I_{w}(t) + I_{BD}(t) \geq I_{load}(t) + I_{BC}(t)\,. \qquad (3.20)$$

Equation (3.20) cannot always be proved. According to various applications, load may not be served with desired amount of energy. This situation is described as loss of load probability (LLP). LLP of the energy system can be calculated using (3.21). Also, LLP is the size of system reliability:

$$\mathrm{LLP} = \frac{\mathrm{EnergyDemand}}{\mathrm{EnergyServed}}\,. \qquad (3.21)$$

The purpose of the optimization procedure is to create a hybrid system that generates power at the lowest cost. The hybrid system model must be optimized for variable solutions and operational strategies to achieve minimal life cycle costs.

3.6 Overview the effectiveness of PV-wind hybrid system

The design was used to design a photovoltaic energy system for health care at the Center for Energy Research. The input parameters of the project are profiles with average data on sunlight, temperature range and wind speed per year.

The material on the lamp system is a test from the Solar Energy Center. Load requirements vary depending on the time of night. To ensure design performance, the algorithm was developed and developed by MATLAB, which will also be a software tool during development. Monthly methods of average daily load are shown in Fig. 3.23. Daily data are calculated using the average speeds of solar and wind energy, and the results are shown in Fig. 3.24 and Fig. 3.25.

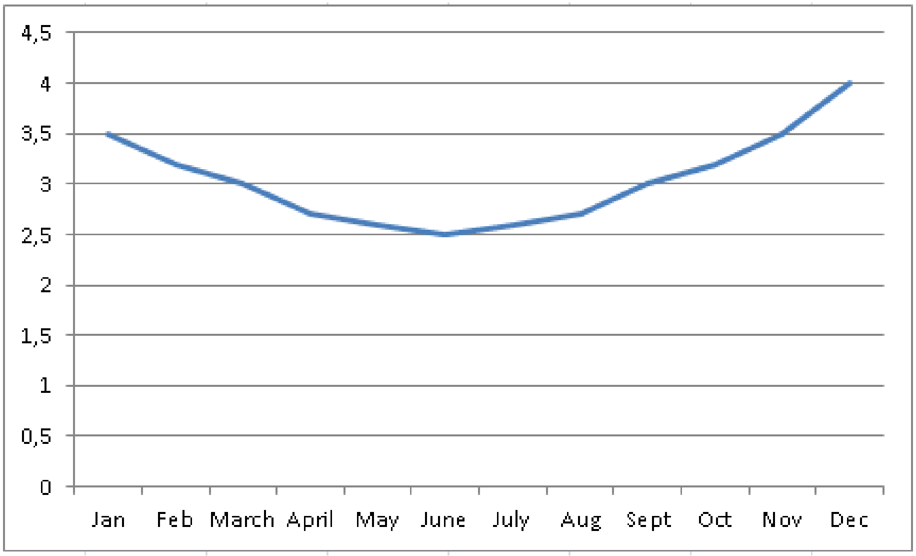


Fig.3.23 - Monthly means of daily load profile of PV-wind hybrid system

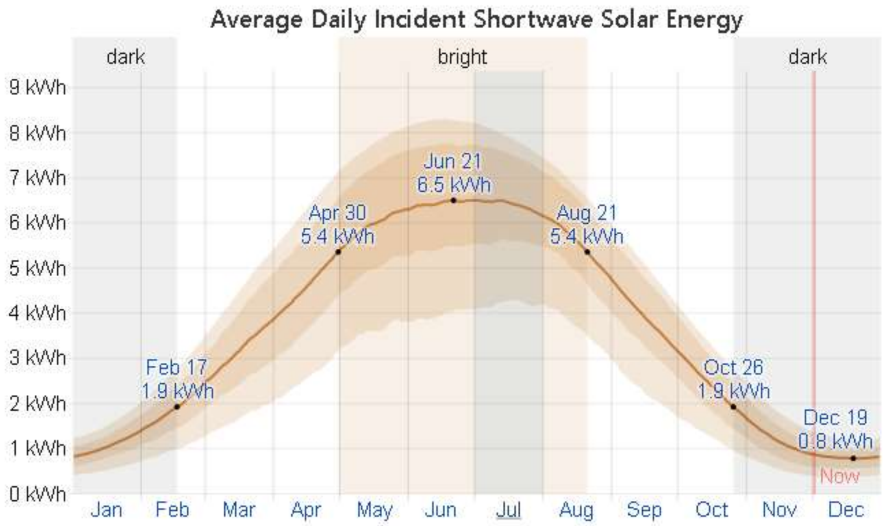


Fig.3.24 - Hourly average of solar radiation data for 12 months of the year at Kiev

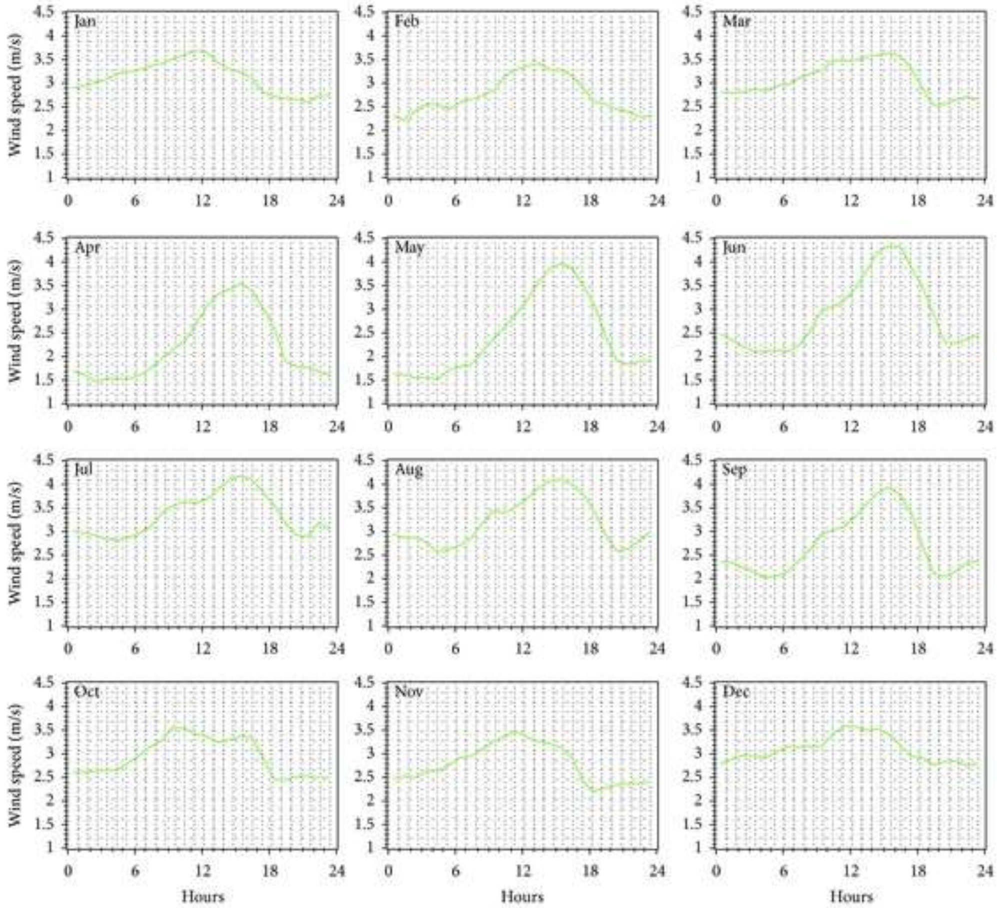


Fig.3.25 - Hourly average of wind speed data for the 12 months of the year at Kiev

Using MATLAB code, the initial values of sizing variables referred to as hybrid system components and type of system components were defined and shown in Table 3.26.

Equation (3.15) was optimized with respect to N_{Bat},N_{pv},N_{wt} , BC_{type}, and operation strategies to minimize the life cycle costs. And then the LLP value was revised to be 0.0738.

Using defined sizing variables and operation strategies, the hybrid system model was simulated according to hourly weather data, and SOC is shown in Fig. 3.27.

Table 3.26 - Hybrid system component's initial values of sizing variables, and type of system components

Variables	Symbol	Initial value or type
Number of series connected modules	N_{SM}	2
Period of operation or duration	T	12 hours
Battery cell voltage	$V_{Bat\text{-}Cell}$	12 volts
Number of series connected batteries	N_{SBatt}	32
PV module type	PV_{type}	SM 50
Wind turbine type	WT_{type}	3 blades
Inverter type	IN_{type}	True sine wave
Battery cell capacity	Q_{cell}	110Ah
Wind turbine power	P_{WT}	500W at 10m/s
PV module power	P_{PVM}	1000W

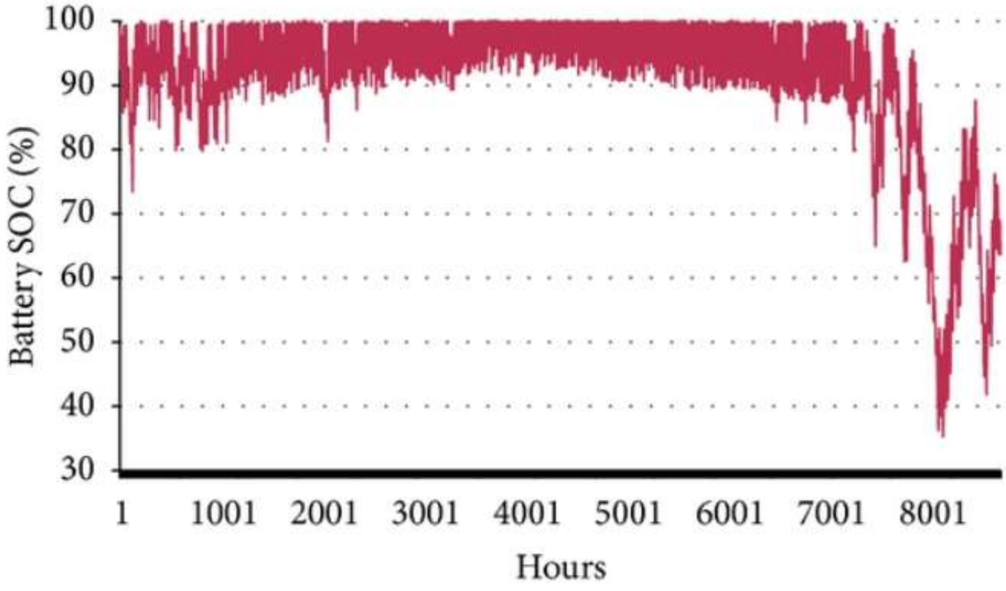


Fig.3.27 - Simulation result of battery SOC

Conclusion: this chapter presents the mathematical models of each component in the system. Also presents hybrid system component's initial values of sizing variables, and type of system components.

CHAPTER 4. Design hybrid power plant and architecture control application

4.1 Design hybrid power plant

A hybrid solar-wind farm consists of different components. Almost every component has its own controller. The wind turbine has a controller that provides protection against overheating and overspeed in the system.The photovoltaic component has pulse width controller. Also our system has a common charge controller. As shown in Fig. 4.1.

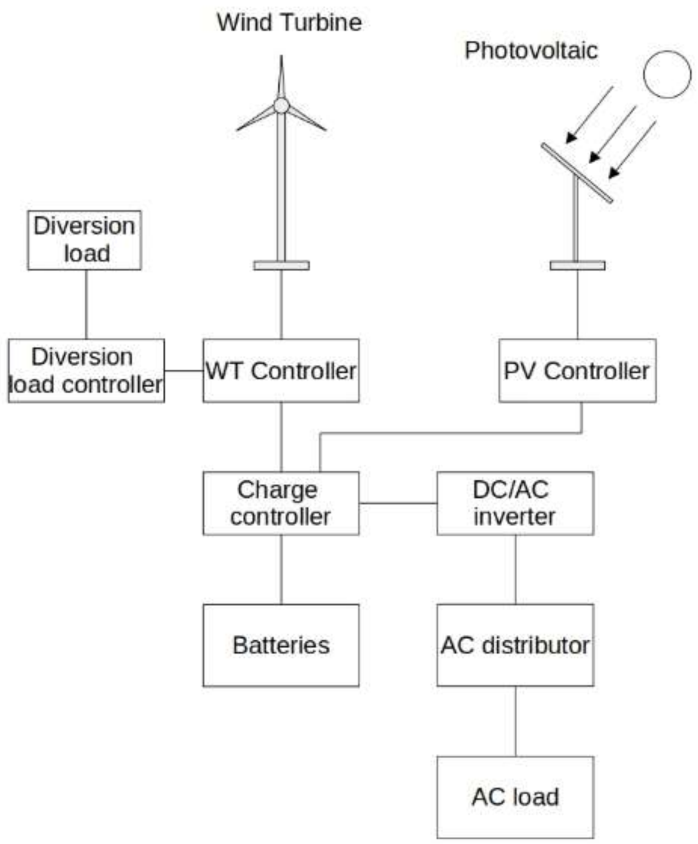


Fig.4.1 – The components wind-solar system

Thus, our system has many different controllers that separately control each component of the system. In conventional systems, these controllers are controlled separately and this is very inconvenient. In my work, I propose to create a master controller that will collect information from each controller in our system. As shown in Fig. 4.2.

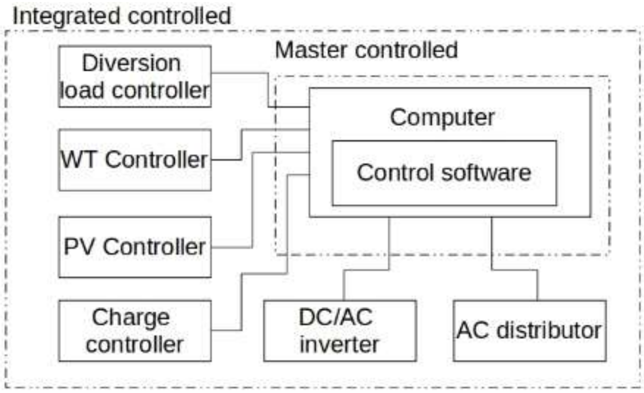


Fig.4.2 – Master controller scheme

After adding the master controller, our system will have the following scheme:

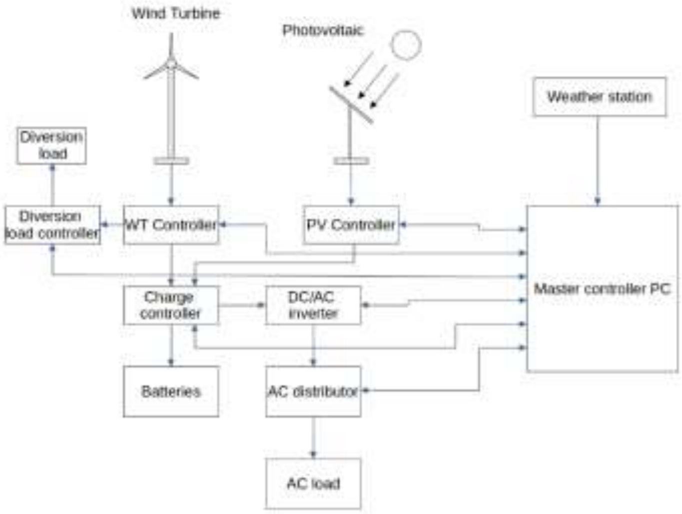


Fig.4.3 – Updated schematic of our systems

4.2 System control application architecture and technologies

To write an application to control our system, I suggest using the Java programming language. Below is a list of libraries, frameworks, database, technologies and tools that are used to write an application.

1. Lombok library

Lombok provides a set of annotations. Some annotations can be used in everyday encodings. For example, @Getter and @Setter annotations provide getter and setter methods for a field, respectively. These annotations can be used at the field and class level. Encapsulating the properties of an object using public getter and setter methods is common practice in Java. Many frameworks rely on this template, and therefore the IDE also supports getter / setter autogeneration and design code.

2. Spring IoC/DI framework

Inversion of Control (IoC), also known as Dependency Injection (DI), is the process by which objects determine their dependencies. In simple words, our objects with which they work, through the arguments of the designer / factory method or the properties that were installed or returned in an industrial way.

Then the container inject these dependencies when creating a bin. This process is fundamentally opposed, and therefore called Inversion of Control, because bin himself controls the implementation and location of their dependencies, using the direct creation of classes.

3. Spring MVC framework

The Spring MVC framework provides the Model-View-Controller pattern architecture with the help of poorly-coupled finished components. The MVC pattern separates the aspects of the application (logic of input, business logic and logic of the UI), while providing a free link between them.

The Model encapsulates the program data, and in general they will consist of POJO ("Old good Java objects", or bin).

View (View, View) is responsible for displaying Model data - typically generating HTML that we see in our browser.

The Controller handles the request that the user sends, creates the appropriate Model and passes it to display in View.

The entire logic of Spring MVC is built around the DispatcherServlet or Front controller, which receives and processes all HTTP requests (from the UI) and answers to them. The processing process for requesting DispatcherServlet is illustrated in the following Fig. 4.4:

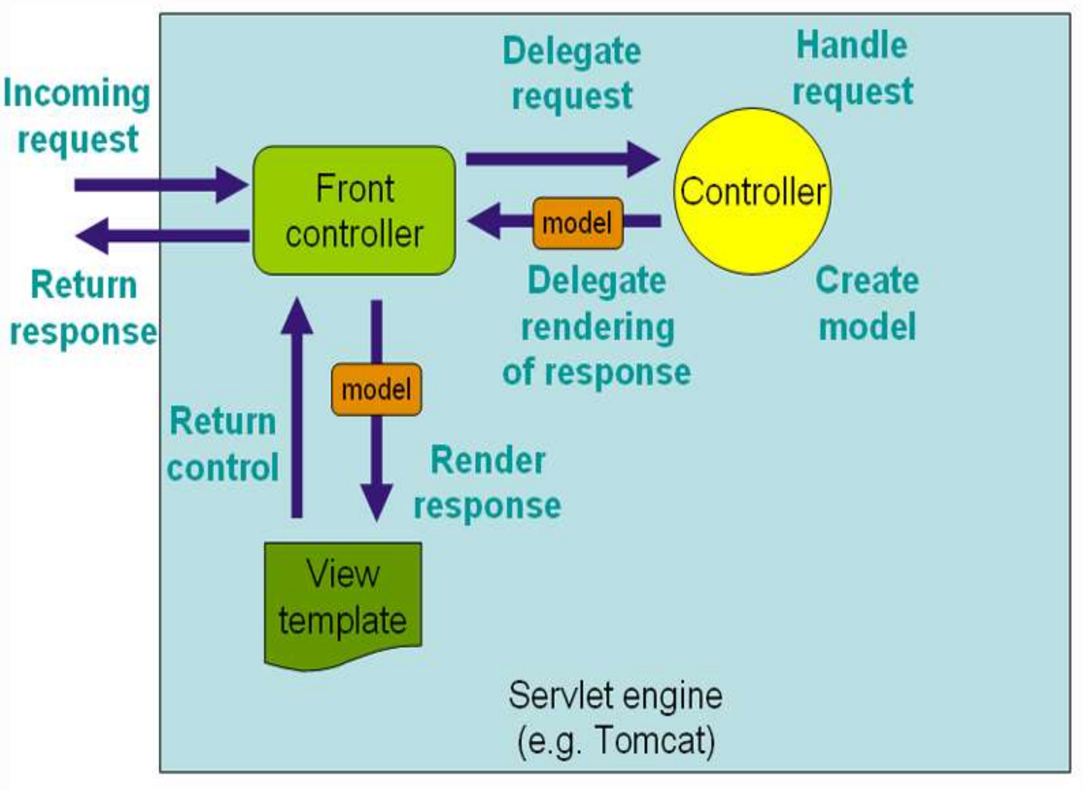


Fig. 4.4 - How the Spring MVC works.

4. Spring Data – JPA framework

Spring Data is an additional and convenient mechanism that we need to interact with the entities of the database, organize them in the repository, extract data, change, in some cases it will be enough to declare the interface and method in it, without implementation.

5. Spring Boot framework

Spring Boot is a very useful framework for simplifying the creation of Spring based applications. It allows us to create the web-application in the simplest way, requiring from the developers at least the effort to configure it and write the code.

The framework has a great functionality, but its most significant features are: dependency management, auto-configuration and built-in servlet containers.

6. MySQL database

MySQL is a free relational database. MySQL has been developed by Oracle and currently supports this technology.

This database is the most popular open source database in the world. Due to its reliability, productivity, and ease of use, the MySQL database is often used for web applications on popular resources such as Facebook, VC, YouTube. In addition, it is often chosen as a built-in database, distributed by thousands of software vendors and hardware vendors.

7. Maven - project builder

Apache Maven is the Apache framework, which is needed to automate the collection of projects. The project collection is based on a description of their structure in files in the POM language, which is a subset of XML.

The Maven project is provided by the Apple Software Foundation, part of the Jakarta Project. Maven is often used to build and manage projects written in C, Java, Ruby, Scala, and other programming languages.

8. GIT – version control system

Git is a distributed version control system. The version control system is the main element in the software setup control system that meets the needs of the project. VCSs allow you to assign alphanumeric or numeric values for certain revisions / updates. They can also provide information about timestamps and have an identifier of changes made by a person.

9. IntelliJ IDEA – development environment

IntelliJ IDEA supports all major JVM application servers and allows deployment and debugging on these servers.

I used the idea because it is a very convenient and smart development environment.

10. JMS – java messaging service that we used to send a message by mail.

4.3 Application operation description and code snippets

Information about our system will be transmitted from the master controller.

Our application will have a WindSolarMainController class that will have 5 access points.

```java
@RestController
@RequestMapping(value = "/WindSolar/api")
public class WindSolarMainController {

    @Autowired
    private HybridSystemFacade hybridSystemFacade;

    @GetMapping("/photovoltaic/temperature")
    public String checkTemperature(@RequestParam final int temp) {
        return hybridSystemFacade.checkTemperature(temp);
    }

    @GetMapping("/photovoltaic/angle")
    public String checkSunAngle(@RequestParam final int angle) {
        return hybridSystemFacade.checkAngle(angle);
    }

    @GetMapping("/wind/speed")
    public String checkWindSpeed(@RequestParam final int speed) {
        return hybridSystemFacade.checkSpeed(speed);
    }

    @GetMapping("/battery/charge")
    public String checkBatteryCharge(@RequestParam final int capacity) {
        return hybridSystemFacade.checkBatteryCharge(capacity);
    }

    @GetMapping("/generation/energy/info")
    public void getGenerationInfo(@RequestParam final String generationInfo) {
         hybridSystemFacade.saveInfo(generationInfo);
    }

```

Fig. 4.5 – The WindSolarMainController class.

Our system is configured in such a way that the controller sends data to the appropriate point in our application. Using the example of transmitting wind speed, I will show how the application works.

Each point has its own path, so the wind speed data falls on /WindSolar/api/wind/speed and then the program processes the transmitted speed.

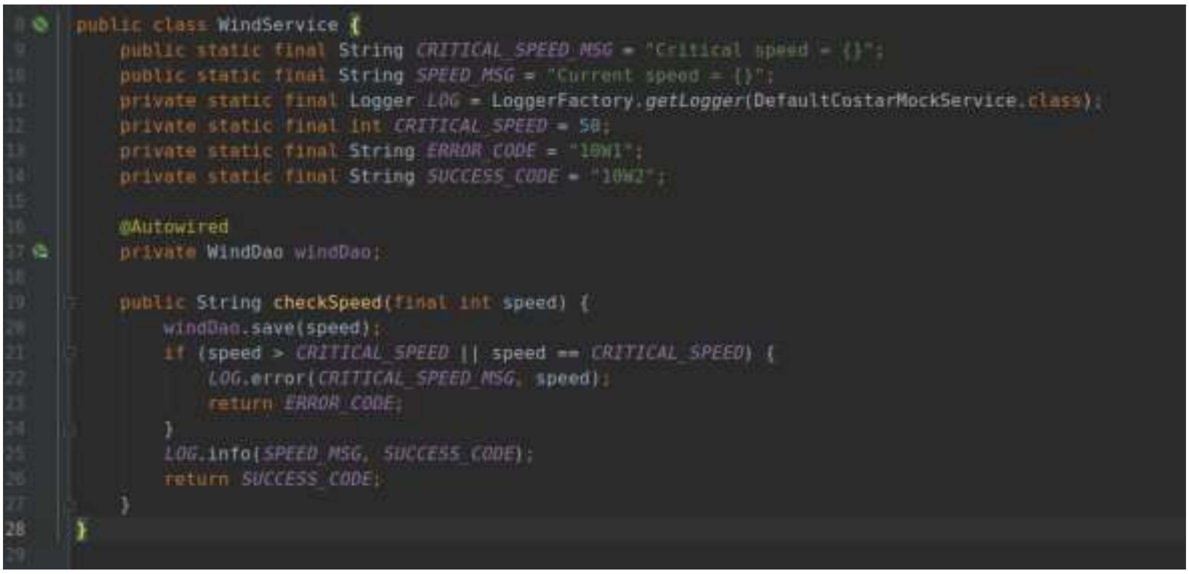
Figure 4.6 shows a HybridSystemFacade class. Through which our controller communicates with the service layer application. Where all the logic is directly executed.

```java
public class HybridSystemFacade {

    @Autowired
    private PhotovoltaicService photovoltaicService;
    @Autowired
    private BatteryService batteryService;
    @Autowired
    private WindService windService;
    @Autowired
    private InformationService informationService;

    public String checkTemperature(final int temp) {
        return photovoltaicService.checkTemperature(temp);
    }

    public String checkAngle(final int angle) {
        return photovoltaicService.checkAngle(angle);
    }

    public String checkSpeed(final int speed) {
        return windService.checkSpeed(speed);
    }

    public String checkBatteryCharge(final int capacity) {
        return batteryService.checkBatteryCharge(capacity);
    }

    public void saveInfo(final String generationInfo) {
        informationService.saveInfo(generationInfo);
    }

}
```

Fig. 4.6 – The HybridSystemFacade class.

Figure 4.7 shows a WindService class. In this class executed the main logic app.The critical speed for our wind turbine is 50 m/s. If the transmitted speed is greater than or equal to the critical one, then we transmit the corresponding code to the controller.

And our controller recognizes this code and thus our wind turbine changes its position. In this class, all values are also logged and saved to the database using the WindDao class. All service classes in the application are arranged in the same structure. Next, I will describe the logic for each service class in the application.



```java
public class WindService {
    public static final String CRITICAL_SPEED_MSG = "Critical speed = {}";
    public static final String SPEED_MSG = "Current speed = {}";
    private static final Logger LOG = LoggerFactory.getLogger(DefaultCostarMockService.class);
    private static final int CRITICAL_SPEED = 50;
    private static final String ERROR_CODE = "10W1";
    private static final String SUCCESS_CODE = "10W2";

    @Autowired
    private WindDao windDao;

    public String checkSpeed(final int speed) {
        windDao.save(speed);
        if (speed > CRITICAL_SPEED || speed == CRITICAL_SPEED) {
            LOG.error(CRITICAL_SPEED_MSG, speed);
            return ERROR_CODE;
        }
        LOG.info(SPEED_MSG, SUCCESS_CODE);
        return SUCCESS_CODE;
    }
}
```

Fig. 4.7 – The WindService class.

For the PhotovoltaicService class, we check the temperature value and the angle of the sun on the panel.

Thus, if our temperature is greater than or equal to 75 ºC, then a change in the crystal lattice occurs in the layers of the absorbing spraying, because of this, the reflection of the sun's rays increases significantly. Due to this, with further heating, the temperature of the coolant increases slightly and does not boil.

Also in this class there is a method that processes the angle of the sun on a solar panel. Thus, solar panels automatically follow the sun during the day and change the angle of inclination of the system. And this significantly increases the generation of electricity compared to fixed-mounted solar panels.

In this BatteryService calss, the battery capacity is transmitted as a percentage. Depending on this indicator, we can monitor the wear of the battery in our system.

Also we have InformationService class. This class does not return any response for the controller. It simply accepts all other data from our system in gson format. Such as the value of generated and consumed energy, etc. It saves all data to a database for analyzing the operation of our system.

In table 4.1 you will see the response codes transmitted by our application.

Figures 4.8 and 4.9 show the algorithms of our system. At the beginning, the controller requests information from the sensors.

In particular, the output voltage and current from the panels and the windmill, the speed of the windmill rotor, power consumption, wind speed, condition and battery level.

Next, the output power of the panels and wind turbines and the total generation are calculated. The wind speed is also estimated for the mode of operation of the windmill. If the wind is not hurricane then the system works in normal mode, if hurricane then the system goes into safe mode.

Next, the generation and consumption of the system are compared. If the generation of energy is less than consumed - we begin to take energy from the battery. If the generation is greater than the consumption - check the condition of the battery and, if necessary, recharge it.

If the battery charge is within 100-80% - all is well, in the range of 80-60% turn off non-priority load (3 priority), from 60 to 40% turn off 2 more priority, at 40 percent turn on the available backup source, such as diesel, and then connect all the load and start charging the battery. If there is no backup source - wait until the sun rises.

Table 4.1 - The meaning of the response codes and the controller's response to them

Response code	Endpoint	Action controller
10W1	/WindSolar/api/wind/speed	Critical speed >= 50 m/s. Wind turbine changes its position.
10W2	/WindSolar/api/wind/speed	Normal speed. Without action.
10P1	/WindSolar/api/photovoltaic/temperature	Critical temp >=75 ºC, then a change in the crystal lattice occurs in the layers of the absorbing spraying.
10P2	/WindSolar/api/photovoltaic/temperature	Normal temp. Without action.
10P3	/WindSolar/api/photovoltaic/angle	Sun angle > 90 or < 90 degree. The solar panel changes its position.
10P4	/WindSolar/api/photovoltaic/angle	Normal sun angle. Without action.
10B1	/WindSolar/api/battery/charge	Battery capacity < 80%. Send message on the mail.
10B2	/WindSolar/api/battery/charge	Battery capacity 80-100%

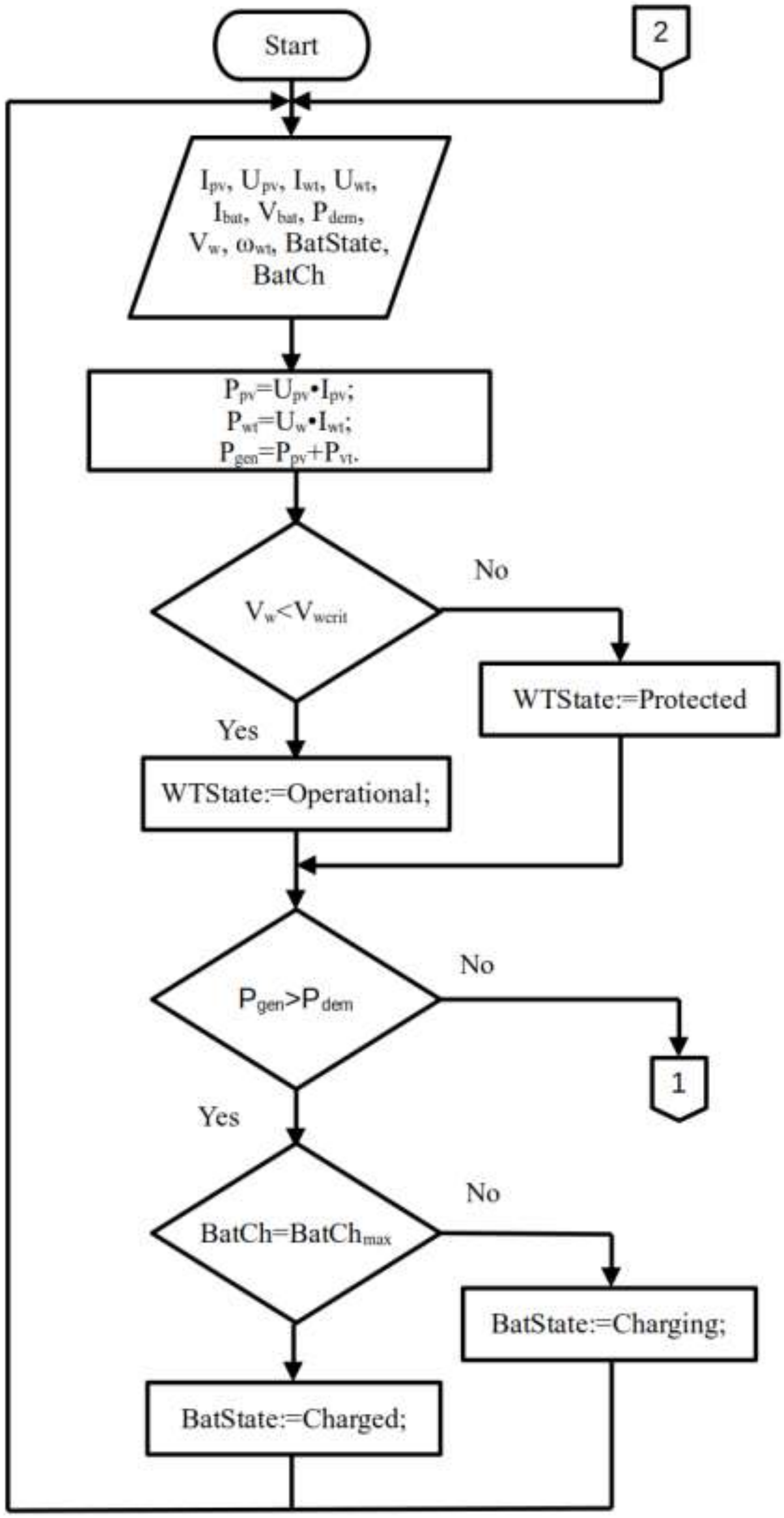


Fig. 4.8 – First block diagram of the installation

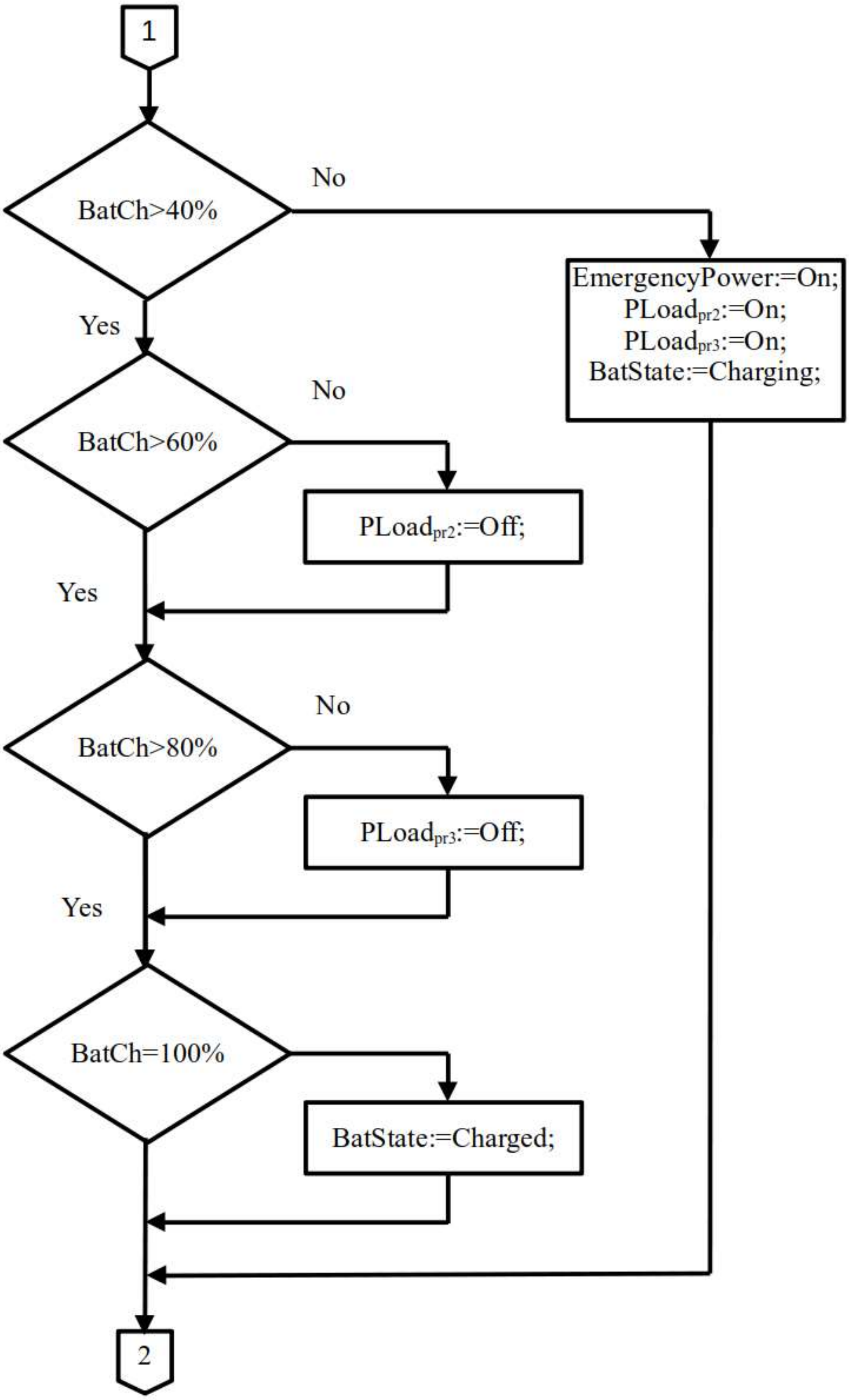


Fig. 4.9 – Second block diagram of the installation

Figure 4.10 shows the interface of our program. It's quite simple, we specify the date in the input field in the format day/month/year. After that, we are given information about our system.

Fig. 4.10 – Simple UI of our program

Data is updated every two hours. You can configure data updates. All this is recorded in the database. We can also specify the data at which the system will respond. For example, set a critical wind mark for our system, the minimum battery charge, and so on.

Conclusion: this section presents the design of a hybrid power plant and the application of architecture management. Describes the architecture of the application, namely the technologies, frameworks and libraries needed to write the application.

CHAPTER 5 OCCUPATINAL SAFETY

5.1. Analysis of harmful and dangerous production factors

The issue of safety of human life must be addressed at all stages of the life of the project, whether it is development, implementation or operation.

Ensuring a safe human life depends to a large extent on the proper assessment of dangerous, harmful production factors. Same complexity of changes in the human body can be caused by various reasons. This may be any factor in the production environment, excessive physical and mental stress, neuro-emotional stress, as well as a combination of these causes.

This chapter addresses the issue of occupational health during the development of a hybrid power plant control system.

The working place for the design engineer is the laboratory of National aviation university ACIC department.

According to standard ГОСТ 12.0.003-74 the following harmful production factors can be identified that affect the employee of this computer laboratory:

- lack or absence of natural light;
- increased noise in the workplace;
- increased or decreased air temperature of the working area;
- insufficient lighting of the working area;

The microclimate of industrial premises is the climate of the internal environment of these premises, which is determined by acting on the human body by combining temperature, humidity and air speed.

According to the requirements of the ДСН 3.3.6.042-99 in the laboratory should adhere to the following indicators. Optimum air temperature is 22 ° C (20-24 ° C is acceptable), the optimum relative humidity is 40-60% (acceptable - no more than 75%), the air speed is not more than 0.1 m / s.

For the creation and automatic maintenance in the laboratory, regardless of the external conditions of the optimum values of temperature, humidity, purity and air velocity, during the cold season, water heating is used, in the warm season, air conditioning is used. The air conditioner is a ventilation installation, which, with the help of automatic control devices, maintains the specified parameters of the air environment in the room.

The work performed with the use of computer technology has the following disadvantages:

- probability of direct glare;
- deteriorated contrast between image and background;
- reflection of the screen.

Due to the fact that the lighting must comply with the standard ДБН В.2.5-28-2006, artificial light should also be used in the workplace. Next, the section will calculate artificial lighting.

Electromagnetic fields characterized by the stresses of electric and magnetic fields, the most harmful to the human body. The main source of these health-related problems of people using automated information systems based on personal computers in their work are displays (monitors), especially electronic-beam displays. They are the sources of the most harmful radiation that adversely affects the health of the design engineer.

In rooms with low overall noise, which is the laboratory where the design engineer works, noise cancellation sources can be ventilation units, air conditioners or peripheral equipment. The long-term effect of these noise negatively affects the emotional state of the staff.

While working on a computer, a design engineer spills a number of dangerous factors that can harm or negatively affect his health. Next, measures are taken to protect against these factors.

Due to НПАОП 0.00-7.15-18, I propose to reduce the time of work on the computer, do breaks the total time of which should be 50 minutes at 8-hour change and, of course, apply protective screens that can protect the human body from electromagnetic fields. To remove the charge, the protective screen installed on the monitor must be grounded.

According to ДСТУ 2325-93 the equivalent sound level should not exceed 50 dBA. In order to achieve this level of noise it is recommended to use sound-insulating wall coverings.

How to reduce the noise can be proposed as follows:

- facing of ceiling and walls with sound absorbing material;
- shielding the workplace (by setting the partitions, diaphragms);
- installation in the computer rooms of the equipment, which makes the minimum noise;
- rational planning of the premises.

Therefore, I propose to use in the laboratory quieter laser printer instead of an inkjet printer, which makes a lot of noise.

The degree of fire resistance of buildings is taken depending on their purpose, the category of fire and fire danger, on the surface, the floor area within the fire compartment.

According to the НАПБ А.01.001-2014, the house where the fire safety laboratory is located in the category B, because there are flammable (books, documents, furniture, office equipment, etc.) and heavy-duty substances (safes, various equipment etc.) that when in contact with fire can burn without an explosion.

According to the structural characteristics of the house can be attributed to buildings with bearing and enclosing constructions of natural or artificial stone materials, concrete or reinforced concrete, where for ceilings it is allowed to use wooden structures protected by plaster or heavy-duty sheet, as well as tiled materials.

Fire extinguishers - technical devices designed to extinguish fires in the initial stage of their occurrence. Fire extinguishers are classified according to the type of extinguishing material used, the volume of the body and the method of supplying the extinguishant.

Powder fire extinguisher - fire extinguisher with charge of fire-extinguishing powder.

Powder fire extinguishers are used in the laboratory, they are intended for extinguishing flammable substances and flammable substances, foam materials (cotton, textiles, insulating materials, etc.), alkaline and alkaline earth metals and their carbides, electrical installations under voltage. The range of use of the extinguisher is determined by the type of powder contained in it.

Caution: powder extinguishers should be used after evacuation of people from the room.

The marginal area of the protected laboratory is up to 100 sq. M. Therefore, after analyzing the data on the standards for the equipment of powder fire extinguishers of industrial and warehouse premises of industrial enterprises, we conclude that for the protection of the laboratory we install 2 powder extinguishers type ВП-8.

The fire alarm system is a set of technical means for detecting fire and notifying the place of its occurrence. It includes fire sensors, receivers, communication lines and power supplies.

According to ДБН В.2.5-56:2014, the smoke fire sensor ІП 212-50М type is installed in the laboratory.

Fire smoke detector optoelectronic autonomous ІП 212-50М is designed to detect fire, accompanied by the appearance of low concentration of smoke in enclosed spaces of various buildings and structures, by registering reflected from particles of smoke of optical radiation and issuing alarms in the form of loud audio signals. The sensor is designed for round-the-clock continuous operation at ambient temperatures from -10 to + 55 ° C.

The sensitivity of the sensor corresponds to the smudge of the environment, which weakens the light flux, within the range of 0.05-0.2 dB / m. Inertia of the sensor operation - no more than 5 s.

5.2. Ways of evacuation from the premises

In the event of a fire, it is necessary to turn off the power supply, call the fire department on the phone, evacuate people from the premises in accordance with the evacuation scheme given in Figure 1 and proceed with the elimination of fire by extinguishers. In the presence of a small fire of fire, you can use improvised means to stop the access of air to the object of fire.

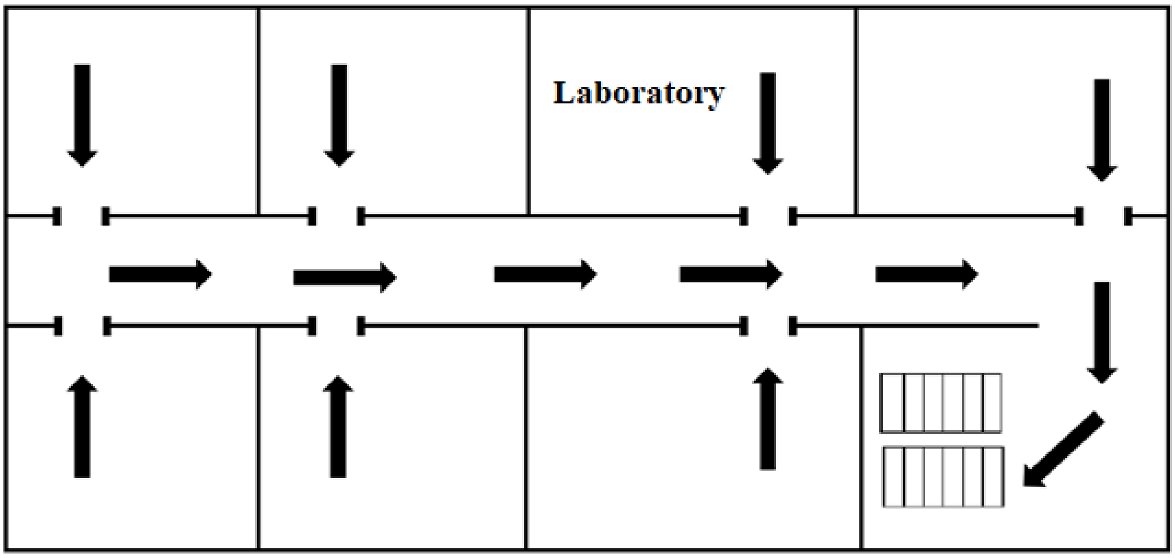


Figure 1. Evacuation scheme

5.3. Calculation part

Calculation of artificial lighting of the laboratory.

Placement of fixtures is determined by the following sizes:

- *H* = 3 *m* - height of the room;
- *hc* = 0,25 *m* - distance of lamps from the overlap;
- *hp* = *H* - *hc* = 3 - 0,25 = 2,75 *m* - height of the lights above the floor;
- *hp* = height of the calculated surface = 0,7 *m* (for premises connected with the work of computers);
- *h* = *hp* - *hp* = 2.75 - 0.7 = 2.05 - design height.

Fixtures of type LDR (2x40 *W*). The length is 1.24 *m*, the width is 0.27 *m*, the height is 0.10 *m*.

- *L* - distance between adjacent lamps (rows of fluorescent lamps), *La* (by the length of the room) = 1,76 *m*, *Lv* (in width of the room) = 3 *m*.

- *l* - the distance from the extreme fixtures or series of fixtures to the wall, *l* = 0,3 - 0,5*L*.

la = 0,5La, lv = 0,3Lv

la = 0,88 m, *lv* = 0,73 m.

Luminaires with fluorescent lamps in the work rooms recommend installing in rows.

The method of the coefficient of light flow is designed to calculate the total uniform illumination of horizontal surfaces in the absence of large darkening objects. Need a flow of lamps in each lamp:

$$F = E * r * S * z / N * \eta, \qquad (1.1)$$

where *E* - given minimum illumination = 300 *lux*, since the discharge of visual works = 3;

r - stock factor = 1,3 (for premises connected with PC work);

S - illuminated area = 30 m^2;

z - characterizes nonuniform illumination, *z* = *Ecp* / *Emin* - depends on the ratio $\lambda = L/h$, $\lambda a = La/h = 0,6$, $\lambda y = Lv/h = 1,5$. Since λ exceeds the permissible value, then z = 1,1 (for fluorescent lamps);

N - the number of lamps, to the calculation. Initially, the number of rows n is scheduled to be substituted for *N*. Then *F* is the flow of lamps of one row;

N = *F* / *F 1*, where *F 1* - a flow of lamps in each lamp;

η - coefficient of use. To find it, the index of the room *i* is chosen and the coefficients of the reflection of the surfaces of the room are estimated approximately

ρ (ceiling) = 70%, ρ (wall) = 50%, ρ (floors) = 30%.

We will get:

$F = 300 * 1{,}3 * 25 * 1{,}1/2 * 0{,}3 = 21450\ lm$

I suggest installing two lamps in a row. Fixtures fit in a row, because the length of a row is about 4 m. We apply lamps with lamps 2x40 *W* with a total flow of 5700 *lm*. The scheme of arrangement of fixtures is shown in Fig. 2.

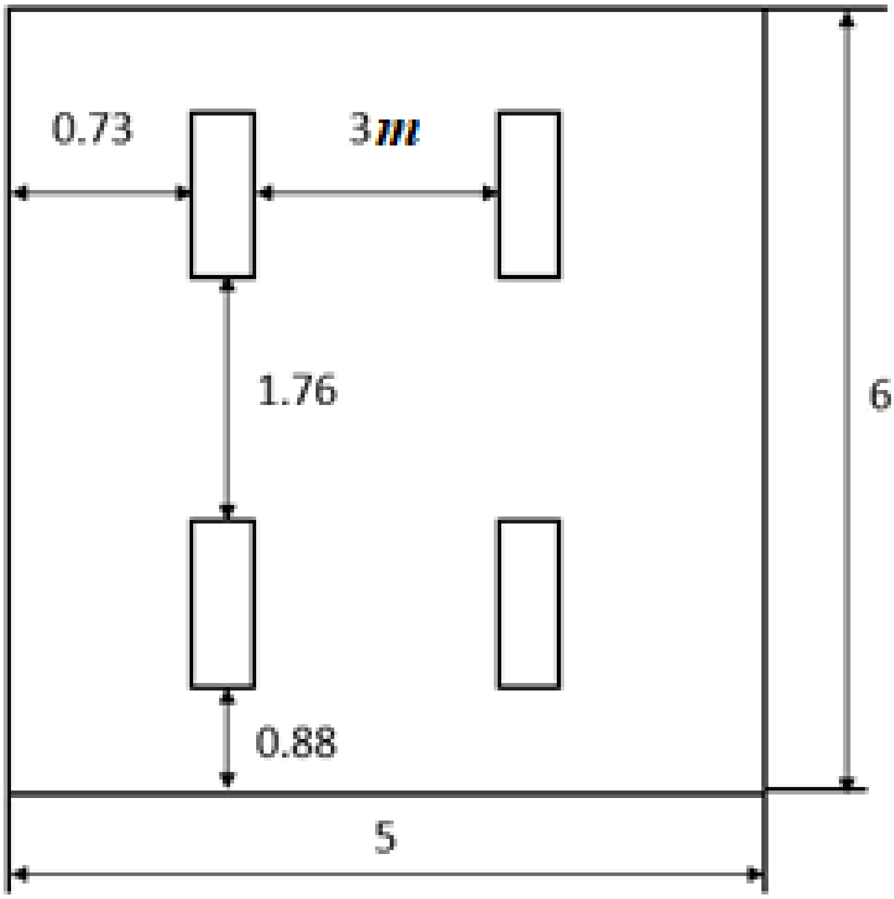


Figure 2. Scheme of fixtures arrangement

5.4. Occupational Safety Instruction

1. General labor protection requirements

1.1. The workplace for working with video terminals must be located so that the field of view of the worker does not get windows, lighting fixtures, surfaces that have the property of reflection. The surface of the desktop should not be polished. To prevent glare on the video monitor screen, especially in summer and sunny days, the video monitor screen should be positioned so that the light from the window falls on the side, preferably on the left.

1.2. The video screen of the PC monitor must be away from the user's eyes (hereinafter referred to as the operator)

1.3. at a distance of at least 500 - 700 mm. The angle of view is in the range of 10-40 degrees. The most rational is the location of the screen perpendicular to the line of sight of the operator.

1.4. The PC must be located at a distance of not less than 1 meter from the heat source.

1.5. The keyboard should be placed on a table surface or a special stand at a distance of 100-300 mm from the edge turned to the user. The angle of the keyboard panel to the horizontal surface should be between 5 and 15 degrees.

1.6. The height of the working surface of the table should be within 680-800 mm.

1.7. The chair must provide the operator with comfortable working conditions and physiological rational working posture during work. The chair must be able to adjust the height of the seat surface, the angle of the backrest and the height of the backrest.

1.8. To protect against direct sunlight, which creates glare on the video monitor screen, sun protection devices must be installed on the windows. The screen of the video monitor should be positioned so that the light from the window falls on the workplace from the side, preferably on the left.

2. Safety Requirements before starting work

2.1. Before starting work, the employee must check the integrity of the enclosures of the system unit, video monitor, printer, keyboard.

2.2. Check the integrity of power cables, their connection points (mains sockets, mains extensions, junction boxes, plugs).

2.3. Prepare your workplace by removing things that may interfere with the work.

2.4. Turn on the PC power.

2.5. If the PC does not boot after the PC is turned on or the computer does not go into operation, the employee must notify the head or specialist of the information technology department.

2.6. If damage or any other defects are found, notify the immediate supervisor. Do not start work without his instructions.

3. Safety Requirements during operation

3.1. It is necessary to stably place all the components of the device on the table, including the keyboard. However, it must be possible to move the keyboard. Its location and angle should correspond to the wishes of the PC user. If the design of the keyboard does not provide space for palm support, it should be placed at a distance of at least 100 mm from the edge of the table in the optimal area of the monitor field. When working on the keyboard, you should sit straight, do not strain.

3.2. To reduce the adverse impact on the user of devices such as "mouse" (forced posture, the need for constant quality control) should provide a free larger surface area of the table to move the "mouse" and a comfortable elbow joint.

3.3. Unauthorized conversations, annoying noises, etc. are not allowed.

3.4. Periodically, when the PC is turned off, dust should be removed from the surfaces of the equipment with a cotton swab slightly moistened with a soap solution. The screen and protective screen are wiped with an alcohol swab.

3.5. FORBIDDEN:

3.5.1. self-repair equipment in which the tube and other elements may be under high voltage (up to 25 kV.)

3.5.2. put any things on the PC hardware, sandwiches and drinks on or next to the keyboard. This can disable it;

3.5.3. cover the ventilation holes in the equipment, it can lead to overheating and failure.

3.6. To reduce the negative impact on the health of employees of various risk factors associated with work on the PC, there are additional regulated breaks for rest of PC users:

3.6.1. after each time of continuous work - 10 minutes;

3.6.2. every 2 hours - 15 minutes.

3.7. In order to reduce the negative impact of monotony, it is advisable to alternate operations of text input and data entry (change the content and pace of work), etc.

4. Safety Requirements after work

4.1. Finish and save the PC files that were in the works. Perform all steps to properly shut down the operating system.

4.2. Turn off the printer and other peripherals, turn off the system unit. If there is an uninterruptible power supply (UPS), turn off its power.

4.3. Turn off the PC with the “POWER” button and unplug the power cord.

4.4. Cover the keyboard with a lid to prevent dust from entering it.

4.5. Bring order to the workplace.

5. Safety Requirements at emergency situations

5.1. If the PC smells burnt or the metal parts of the PC are exposed to electric shock, unplug the PC immediately and notify your supervisor.

5.2. In case of fire, immediately start extinguishing with available fire extinguishing means and notify by phone 101 (city fire department) and the head of the DPD of the enterprise. Remember that extinguishing electrical installations should be carbon dioxide fire extinguishers, dry sand to avoid electric shock.

5.3. In case of injury, stop work, provide first aid, call an ambulance by phone 103, if necessary, take to a hospital.

5.5. Conclusion

During the work on that chapter, an analysis of the hazardous and harmful factors affecting the design engineer during his duties. A number of measures to reduce the impact of negative factors that negatively affect the design engineer from the time of work have been proposed.

Also, the calculation of artificial lighting of the workspace of the design engineer was made and on the basis of calculations it was proposed to install in the laboratory two arrangement with lamps 2x40 *W* with a total light flow of 5700 *lm*.

CHAPTER 6. ENVIRONMENTAL PROTECTION

6.1. Introduction

The final result of the diploma project is to devevelop of a hybrid power plant control system. Our system contains wind turbines are tall mechanical structures with rotating blades that look like windmills. Wind makes the blades rotate, and the energy generated is converted to electrical power. Also in our system include the solar plant.

In this chapter, the effect of noise from wind power plants and the effect temperature solar plant on them efficiency will be considered.

6.2. Characteristics of sound

Sound is produced by vibrations which cause pressure changes in an elastic medium, such as air. The resulting waves of pressure travel in all directions away from their source . When these sound waves fall on the human ear, the sensation of hearing is produced . Audibility refers to whether or not a sound can be heard; sounds which we can hear are audible; sounds which we can not hear are inaudible. Noise is unwanted sound; “sound which is disagreeable, discordant or which interferes with wanted sound”. This is subjective and depends on the listener; a noise for one person can be a sound for another. Environmental noise (also known as noise pollution) can be caused by air and road transport, industry, and commercial and domestic activities. Sound has a number of properties which affect the way it is heard and interpreted. These are described in the next sections.

6.2.1. Sound pressure level

The higher the pressure of a sound, the louder it seems to the listener (although “loudness” also depends on other factors).

“Sound pressure level” refers to the pressure of the sound when measured in the decibel (dB) scale. It is also simply referred to as “sound level”. Sound pressure level is dependent on:

- the amount of sound produced by the source of the sound;
- the distance from the source at which the sound is heard or measured (the sound level decreases as the sound travels away from its source);
- the effects of the surrounding environment on the sound waves (sound travels better in some environments than others).

However, the sound pressure level does not change according to who is listening to the sound; it is therefore an objective property, which can be measured by an acoustician.

6.2.2. Loudness

Loudness refers to how intense a sound seems when heard by the human ear. Loudness is related to the sound pressure level, but also depends on other factors, such as the frequency, duration and character of the sound. Interpretation of loudness can vary between people; it is therefore a subjective property of the sound.

6.2.3. Frequency

Frequency (also referred to as pitch) is the rate of repetition of the pressure wave. Frequency is measured in Hertz (Hz) or cycles per second. Higher frequencies have a greater number of sound waves (or cycles) per second than lower frequencies; this is illustrated in Figure 6.1. Bass instruments, such as the tuba or double bass, produce sounds of a lower frequency (or pitch) than smaller instruments such as the flute or violin. For example:

- the lowest note of a double bass is 41 Hz;
- the highest note on a piano is 4,186 Hz;
- most human speech is in the range 300–3,000 Hz.

Sounds can be grouped into categories according to frequency, as shown in table 6.1.

Table 6.1. Frequency categories of sound

Infrasound (very low frequency sound)	Below 20 Hz
Low frequency sound	Below 200 Hz
Mid frequency sound	200–2,000 Hz
High frequency sound	2,000–20,000 Hz
Ultrasound	Above 20,000 Hz

Most sounds contain a mix of many frequencies. Sounds with mostly low frequencies often sound like a rumble, for example, thunder. Sounds with mostly high frequencies often sound like a buzz or whine, for example, mosquitoes.

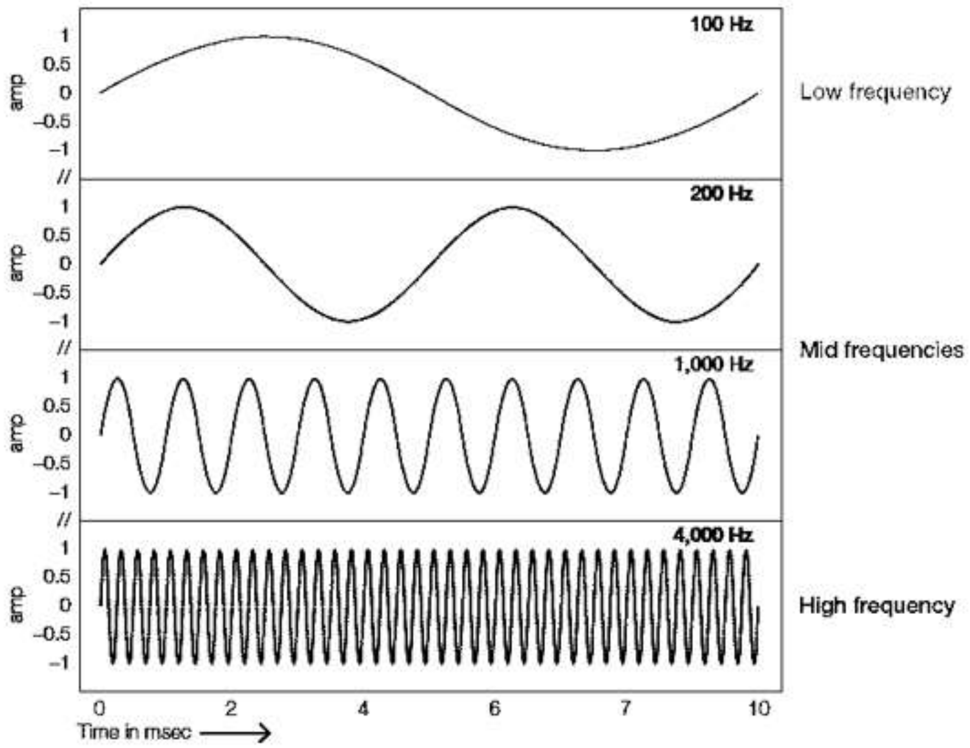


Figure 6.1. Sound waves of different frequencies

6.3. Analysis of sounds that produced by wind turbines

6.3.1 Source of wind turbines sound

Wind turbines generate mechanical and aerodynamic sounds. Mechanical sounds come from the internal machinery and may also be generated from a faulty component. Mechanical sound from turbines has decreased significantly over time as turbine design has improved.

Aerodynamic sound is generated by the rotation of turbine blades through the air, and is the main source of sound from wind farms.

6.3.2. Variability of wind farm sound

It is hard to generalize about wind farm sound, because the level, character, and frequency of the sound depend on a number of factors. These factors vary within and between farms. They include:

- Distance from the nearest turbine or cluster of turbines;
- Number of turbines on the wind farm (or in the nearest
- cluster, if the farm is very large);
- Model, size and arrangement of the turbines (for
- example, larger turbines produce higher sound levels);
- Topography of the surrounding land;
- Wind speed and direction.

Computer models of wind farms prior to construction take account of all these factors and predict noise levels likely to result from the turbines at different locations. This influences the type of turbines used, the placement of the turbines and their operating conditions. Sound measurements taken after construction can then be compared to predicted measurements.

6.3.3. Wind farm sound levels

While it is difficult to generalize, the sound pressure levels from wind farms at the distance of most neighbouring residents (for example, 500–1,000 m from the nearest turbine), are lower than those of many other sources of environmental noise.

6.3.4. Frequency of wind farm sound

Aerodynamic sound from wind turbines contains many different frequencies. The dominant frequencies are in the 200–1,000 Hz range. A mid to high frequency intermittent ‘swish’ is the main sound heard within approximately 300 m of a wind turbine. Low frequency sounds may be at a level just above the hearing threshold, and may become more noticeable than the “swish” further away from the turbine.

Figure 6.2 shows that levels of infrasound from the two wind farms (red and yellow curves) are 20 dBG lower than the audibility threshold (green curve). In conclusion, there is overwhelming evidence that infrasound from wind farms is at levels which are too low to be audible, and no higher than background levels in the environment.

6.3.5. Turbine design

Variations in the make, model and configuration of different wind turbines result in sounds of different frequencies and characteristics. Larger turbines (2.3–3.6 MW) emit slightly lower frequency sound than smaller turbines. However, the sound produced by large turbines has not been found to be more annoying than that from smaller turbines. There are currently no turbines of this size operating in Victoria, but several projects are planned with larger turbines. Newer designs aim to reduce the amount of sound produced. For example, larger turbines produce less sound per MW of energy than small turbines.

Modern turbine models, which have the blade in front, are less noisy than older “downwind” models. Upwind turbines also produce much lower levels of infrasound than downwind turbines. All modern turbines in Australia are designed to be upwind.

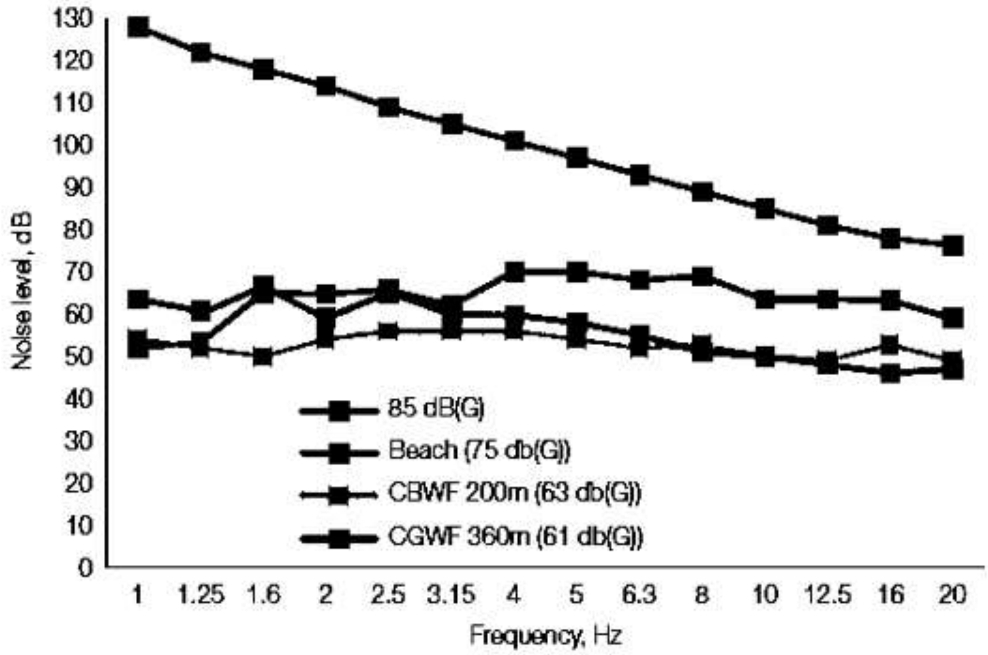


Figure 6.2. Infrasound measurement results from two Australian wind farms (measured at 61 and 63 dBG) compared against measurement results at a beach (75 dBG) and the internationally recognised audibility threshold of 85 dBG

6.4. Analysis of the noise effect on health

6.4.1. Non-auditory health effects of noise

Exposure to unwanted sounds, of any frequency, may cause non-auditory health effects. There is good evidence that environmental or community noise can lead to:

- annoyance;
- sleep disturbance;
- cardiovascular disease (including high blood pressure

and ischaemic heart disease);

- tinnitus;
- cognitive impairment in children.

6.4.2. Cardiovascular disease

There is growing evidence that exposure to road and aircraft noise may increase the risk of high blood pressure. There is weaker evidence of an association with myocardial infarction (heart attack), which is not seen until sound levels become quite high. However, the noise levels associated with these observations are much higher than those near wind farms. Few studies have addressed sources of environmental noise other than transport noise. The mechanisms by which environmental noise may cause cardiovascular disease are unclear, but long term stress is likely to play a role.

6.4.3. Annoyance and sleep disturbance

These are the key health impacts of noise, together accounting for the vast majority of the burden of disease due to noise. Annoyance is a broad term used to describe negative reactions to noise. Such negative reactions are more diverse than simply being 'annoyed' or irritated by noise; they may develop into anger, depression, agitation and helplessness, and can thus have a significant impact on quality of life.

Annoyance and sleep deprivation may contribute to a physiological stress response (putting the body into an alert "fight or flight" mode) that can modify the cardiovascular system and hormone levels in the short term. Stress experience over a long period of time (chronic stress) may contribute to the development of mental illness and cardiovascular disease. Feeling stressed is likely to further impair sleep and increase annoyance, exacerbating the effects of a noise disturbance.

A low level of audible sound, such as that produced by wind farms, is not a problem for most people. However, people may develop a negative reaction to sound due to a number of factors, relating to either the noise itself, or the individual's response to the noise.

6.4.4. Acoustic factors: factors relating to the noise itself

Acoustic factors which may contribute to annoyance include sound level and the special audible characteristics (SACs) of the sound. Unsurprisingly, a higher sound pressure level is associated with a higher degree of annoyance; that is why there are regulations that set limits on sound levels for different sources of sound (including wind farms). As described before, SACs of wind farms such as amplitude modulation, tonality and impulsivity may increase the annoyance above that expected for a particular sound level.

6.4.5. Non-acoustic factors: an individual's response to noise

Individuals perceive and react to noise very differently. For example, a dripping tap in the night may be unbearable to one person and barely noticeable to another. Non-acoustic factors can contribute more to annoyance and related health effects than the level of the noise itself.

The following factors influence how an individual reacts to noise:

- attitude to the source of the noise;
- noise sensitivity;
- perceived control over the noise and degree of trust
- in relevant authorities;
- history of noise exposure;
- existing health and wellbeing.

Figure 6.3 illustrates the complex ways these factors interact and how they influence annoyance, stress and other health effects.

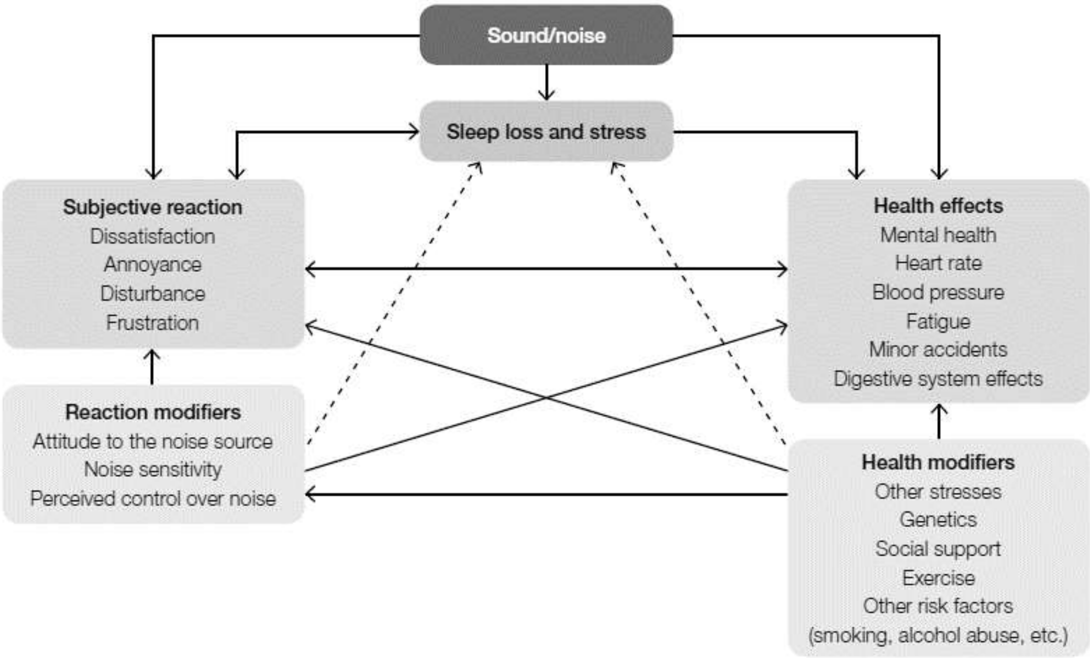


Figure 6.3. A model of the causal connections between noise, community reaction, modifiers and health effects

Because of the importance of non-acoustic factors in the development of annoyance, decreasing the exposure to a noise source does not always decrease the level of annoyance experienced.

6.5. Influence of solar temperature on their efficiency

When the surface of the solar battery is heated to a high temperature, its performance is significantly reduced. Therefore at installation provide a possibility of natural ventilation of panels, especially its back part. Less exposed to temperature solar panels with double glazing (Double Glass modules), in which the two walls - the back and front - glass. The efficiency of solar panels with double-sided glazing is higher than that of conventional panels.

The electrical parameters of any solar cell are determined in the so-called standard test conditions, namely at a solar radiation intensity of 1000 W / m2 and an operating temperature of 25 ° C photocells.

With the general trend of decreasing power output with increasing operating temperature, each type of solar panels behaves differently. Thus, in silicon cells, the nominal power decreases with each degree of excess of the nominal temperature by 0.43-0.47%. At the same time, elements of cadmium telluride lose only 0.25%.

As the temperature of the photocells increases, the values of the main characteristics of the module (no-load voltage and power) deteriorate. Photovoltaic cells convert solar radiation, the wavelength of which differs from the spectrum required by the thermal collector to heat the coolant. When operating solar panels without thermal removal, the infrared component of solar radiation is used to heat the photocells, which often leads to their overheating and falling photovoltaic efficiency (sometimes up to 20-30% compared to the passport data). Similarly, elevated temperatures can lead to the destruction of sealing materials, which in the future will affect the quality of the system and the efficiency of solar panels.

When heat is removed from the photoconverters, their performance improves (efficiency and other characteristics correspond to the passport data). As can be seen from the review of literature sources, due to the cooling of photocells it is possible to maintain their passport characteristics, to prevent their deterioration. Naturally, this effect will be more significant for systems with solar concentrators, because the heat density due to the absorption of solar radiation increases approximately in proportion to the degree of concentration.

Table 6.1 - Dependence of characteristics of the ISM50 photomodule on temperature

Temperature ,°C	Power, Wt	Voltage, V	Current, A
25	50	17	2,88
45	44,8	15,44	2,9
60	41,5	14,27	2,91

The temperature of the solar cell is one of the factors influencing the efficient operation of a solar power plant. So on a frosty winter day, the generation of a solar power plant can be significantly more than on the same sunny but hot summer day (provided the optimal angle of the solar panels in both cases).

To explain the difference in generation at the same levels of solar radiation, consider the effect of temperature on the efficiency of photovoltaic panels.

An important point of operation of solar cells is their temperature. When the element is heated by one degree above 25 C, it loses a voltage of 0.002 V, 0.4% / degree. On a bright sunny day, the elements heat up to 60-70 C, losing 0.07-0.09 V each. This is the main reason for the decrease in the efficiency of solar cells, leading to a drop in voltage generated by the element.

Increasing the temperature of the solar cell can lead not only to a decrease in the power generated, but also to the impossibility of functioning of the solar power plant as a whole system. This is due to the fact that in the case of the design of a solar power plant, the selection of equipment is often based only on the general technical characteristics specified in the technical documentation, without taking into account the temperature characteristics.

Consider the options when a significant change in the temperature of the solar panel can affect the practical implementation of the solar station. In cases where solar panels are used to charge batteries, it is necessary to make sure that the voltage produced by the solar battery in hot weather will not be less than the voltage of the batteries. Otherwise, the batteries will not be charged. It should be borne in mind that a significant decrease in ambient temperature, and hence the solar cell, which can lead to disconnection of the charge controller or inverter due to exceeding the allowable value of the no-load voltage or a separate series of solar panels.

To prevent a decrease in the efficiency or failure of the solar power plant equipment, when calculating the parameters connected separately or several series-connected solar panels, it is necessary to take the no-load voltage of the solar battery, taking into account the most unfavorable operating conditions. The voltage of the solar battery increases with decreasing temperature, and the connection scheme must provide a voltage that does not exceed the allowable even at the lowest temperatures.

The problem with existing hybrid solar collectors is that for efficient operation of photovoltaic cells the required temperature is 25 C. And for efficient use of heat of the coolant at the outlet of the collector it is necessary that its temperature was 60-70 C.

6.6. Conclusions

This chapter outlines some key concepts regarding the sounds emitted by wind farms and their potential health and temperature effects on the efficiency of a solar power plant:

• The predominant sounds emitted by wind farms are medium and high frequencies. The sound of a wind farm, including a low bass sound, can be heard by nearby residents.

• Sound noise from any source, including wind farms, can cause irritation, leading to prolonged stress and other health consequences. The potential for health effects depends on acoustic factors (including sound pressure levels and other noise characteristics) and non-acoustic factors (including individual noise sensitivity and attitude to the source).

• Increasing the temperature of the solar cell can lead not only to a reduction in the power generated, but also to the impossibility of the solar power plant to function as a whole system. This is due to the fact that in the case of the design of a solar power plant, the selection of equipment is often based only on the general technical characteristics specified in the technical documentation, without taking into account the temperature characteristics.

CONCLUSIONS

In the thesis different types of hybrid energy systems and their components were analyzed.

Also in the work the structure of the controller which would carry out the general management of system is offered

The algorithm of the controller operation which provides control of a condition of system, automatic protection of wind generators against hurricane winds, management of loading of system depending on a charge level of accumulators in the absence of generation of energy, automatic switching to reserve power supplies in case of emergencies is developed.

A system software architecture has also been developed which has the following advantages:

1. Easy to use.
2. All frameworks, libraries, build tools and plugins are free and are freely available.
3. Due to the correct architecture, the program is very flexible and easy to make changes.
4. In order to collect all the data from the sensors, we use another controller that is directly integrated with the program to control the installation.
5. Prevent critical breakdowns of the wind power installation.

Thus, the use of hybrid renewable energy systems is a promising solution for decentralized power supply in rural and remote areas.

With the help of the program we will be able to manage the system, collect all the data we need. To monitor the operation of the station and in conditions of hurricane winds or inclement weather conditions, the system is able to move safely based on sensor data using internal algorithms.

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