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OF THE REPUBLIC OF KAZAKHSTAN

Rudny Industrial Institute

Department of Electric Power Engineering and Heat Power Engineering

KHABDULLIN A.B.

EDUCATIONAL SOURCE

" RENEWABLE ENERGY SOURCES "

for students of the specialty "Power Engineering"

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Reviewers: Barulin Alexander Ivanovich Candidate of Technical Sciences, acting. Associate Professor of the departments of PIandP S of the Rudny Industrial Institute
Naberekutina Natalia Sergeevna Ph.D., associate professor of the departments of PIandP S of the Rudny Industrial Institute

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The manual contains the main theoretical information on renewable and resource-saving energy sources such as wind power plants and solar panels. Schemes of wind power plants and solar panels are shown. Experimental studies based on the selected and established weather station of the Davis Vantage Pro 2 type are presented. The sections give theoretical positions that allow us to elucidate the mechanism for converting solar and wind energy energy into electricity.

The manual is intended for university students, masters, teachers studying the procedure for obtaining the "Energy of the Future". Assist a wide range of specialists studying the application of alternative energy sources.

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CONTENTS

INTRODUCTION

The development and improvement of renewable energy sources are conditioned by the need to form a new energy model, diversify the technological base of power generation, replace energy shortages and solve global environmental problems. The global demand for renewable energy sources (RES) is constantly growing. By 2050, their share in the global energy balance is projected to increase to 35%. The main advantages of RES - inexhaustibility and environmental friendliness and served as a reason for the rapid development of renewable energy abroad and very optimistic forecasts about its prospects in the coming decades.

The main reasons for the development of renewable energy are ensuring energy and environmental security, preserving the environment, conquering world markets for renewable energy sources, preserving reserves of own energy resources for future generations and increasing the consumption of raw materials for non-energy use of fuel. The use of renewable energy has become an important and indispensable direction for the development of the energy sector of the future. Kazakhstan has all the necessary resources. Taking into account the electricity deficit in the country, especially in the southern regions, the widespread use of alternative sources is becoming important. The use of renewable energy will reduce the cost of providing electricity to remote settlements, significantly save on the construction of new power lines.

The Rudnenskiy Industrial Institute is developing a strategy on the topic "Development of energy-saving technologies and equipment for industrial-technological development of the industrial complex of the North-West region of Kazakhstan" [16,19]. The urgency of the topic is to take urgent measures to implement the global energy and environmental imperative, which consists in the daily innovative development of available energy technologies. One of the directions of the strategy is an objective assessment of the efficiency of energy resources use and development of specific recommendations for its increase with a view to conducting research in the field of analysis, search and implementation of renewable energy sources.

In this direction, the Department of Power and Heat Power Engineering of the Rudny Industrial Institute is working. Advantage of the conducted engineering researches of the chair "Power engineering and heat power engineering" is the choice of the construction site on the territory of the university with the purpose of introducing the "Wind power installation" and "Solar thermal device" into the educational process for the main and auxiliary buildings of the university. It is proposed to install the selected "Wind Turbine" and "Solar Thermal Unit" on the territory of the "Training Ground" of the Rudny Industrial Institute.

1 Analysis of the use of renewable energy sources

1.1 The role and importance of the use of renewable energy sources

The electricity supply to industrial consumers (PP) is a priority task for ensuring sustainable development of the economy of the Republic of Kazakhstan. The large length and branching of power lines, the deterioration of electrical networks cause significant losses of electricity. In the result, there is an increase in the cost of electricity supply to industrial enterprises (PP).

Increasing the efficiency of power supply PP is the development of distributed generation (RG), which is a low-power power plant, located in the vicinity of consumers and using local energy resources. At the same time, the development of the WG is possible on the basis of the use of renewable energy. The most promising renewable source of accessibility for PP is the energy of the wind and solar flux.

In the world there is a huge fleet of wind power installations (VEU) and solar panels (SE), the installed capacity of which is more than 300 GW [4]. The development of wind power and solar panels is due to the use of wind power plants (WED) of medium and high power, installed in areas with high wind speed and the manifestation of solar activity.

In areas with low wind speeds, low-power wind turbines (up to 100 kW) are topical. The data of the wind turbine do not allow the generator to be connected to an electrical network without a converter device.

The use of windmills and solar panels of low power is currently insufficiently investigated and are relevant. Increasing the efficiency of PP power supply by using wind power plants of low power as part of the wind power station and solar panels is the main task and is necessary for the preparation of highly skilled personnel in the heat and energy sector [17, 18].

The research tasks are:

- Analysis of wind energy systems, solar panels and weather stations;
- Definition of the main indicators of windmills, parameters of the EaP and VES, affecting the efficiency of power supply PP;
- On the basis of experimental data, investigate the output parameters of a small-capacity wind turbine generator and solar panels;
- Definition of technical and economic indicators of low power wind turbines and solar panels, development of recommendations for their selection in the power supply system of PP;

When studying the discipline "Renewable energy sources" it is possible to familiarize students with the design, basic elements, the field of application of solar panels and weather stations, it is necessary to develop practical skills in setting up, assembling, disassembling, assembling structures from solar panels, getting skills in setting up weather stations, indications and analysis of results. To study problem questions when working with solar panels and a weather station. The manual is intended for conducting lecture and practical classes. The goal is to give a simple presentation of the section "Solar Panels and Vetorovstanovka".

A solar battery or a solar panel is a device consisting of a group of photocells connected to each other and made in one housing. The converted solar energy comes to the output of the battery in the form of a constant electric current. In view of the fact that one solar panel can produce a limited amount of electrical energy, systems consisting of several panels (modules) are often used.

Meteorological station - a set of different instruments for meteorological measurements (weather observations). There are analogue and digital meteorological stations. The wide use of solar panels opens up fundamentally new opportunities in the field of power generation.

The task of creating and successfully operating solar panels can be solved not only with the availability of appropriate technologies and means, but also with the availability of appropriate personnel. In this case, the specialist should be able to apply modern techniques in the design, installation, repair and also in the creation of power supply elements with the help of solar panels and wind turbines.

1.2. Use of non-traditional energy sources

The section presents an analogue of the PP power supply system, the features of wind energy development and the experience of using wind turbines. At present, industrial electrical networks are in a worn condition. In view of the large length of distribution networks 10-0.38 kV, losses of electric power during transmission and, consequently, the cost of electricity are growing.

The WG allows you to reduce power losses during transmission. As a WG can serve as a wind turbine. Using wind energy saves organic fuel and reduces the cost of consumed electricity PP. Experience in the use of wind energy is accumulating in the world and in the RK. Prominent scientists contributed to the development of wind energy: NE Zhukovsky, G. Kh. Sabinin, VN Andrianov, EM Fateev, and others, and the work of P. Bezruki, LA Saplina, Ya.I. Sheftera and others.

The use and application of a wind turbine and a solar thermal device for electricity supply to social facilities is one of the promising areas in alternative energy. Conducting research in the field of renewable energy sources will contribute to the fulfillment of the objectives of the State Energy Saving Program for the period until 2020 and the introduction of "Green Energy" in the Republic of Kazakhstan.

At present, there is an increasing interest in the world in the use of non-traditional renewable energy sources (NVEI) in various sectors of the economy. There is a great discussion about the choice of ways to develop energy. It is connected with the limited nature of fuel reserves, environmental pollution, negative environmental consequences of traditional energy, stably high world prices for oil and other energy resources. Renewable energy is seen as one of the real alternatives to traditional energy sources.

Analysis of domestic and foreign sources in scientific and technical publications shows that the use of non-traditional renewable energy sources varies

widely. "Green" calls to replace all traditional fuel and nuclear power engineering with the use of NIEE.

In the articles of Belyaev Yu.M. "Problems of long-term development of power engineering" revealed the advantages and disadvantages of NIEE. The positive qualities of NRW include: environmental cleanliness and free energy, and negative signs include: weather conditions, remote areas, a large cost of energy.

Let's consider separately: geothermal power, wind energy, solar energy, biomass energy, small hydro power, use of low-potential energy.

Geothermal energy - manifestations of thermal energy of the bowels, heated gases and vapors, the heat of some rocks, and volcanic heat. Geothermal energy is independent of the time of the year, the day, the meteorological conditions.

An analysis of the work of scientists in this field shows that the application of geothermal energy has its drawbacks. Water vapor, sulfur, boron, mercury and other substances are emitted into the atmosphere, soil and water are polluted.

Therefore, the development of geothermal energy should be carried out in a package of measures to protect the environment. Wind energy is an environmentally safe and efficient, quite powerful and affordable energy source that does not require coal, gas and other expensive energy resources. The main factors that determine the possibility of using wind energy include meteorological conditions, the choice of the optimal location of wind turbines, the method of converting the kinetic energy of wind into electrical and economic efficiency. Wind energy development is favorable for Almaty, Karaganda, Kostanay regions. The scientist Bezhan A. V. considers the possibilities of organization of heat supply with the participation of wind power units of different power, and gives an estimate of the energy saving effect obtained. In the works of Syrkin V. V. "Wind power - from the past through the present to the future" [1] presents detailed historical information on the development of wind power from the deep antiquity of human civilization to the present day.

Solar energy is a branch of science and technology that develops the fundamentals, methods and means of using solar radiation or solar radiation for obtaining electrical, thermal and other types of energy. Developed in the RK is weaker than wind power, which is explained by the significant specific investments in solar power plants and power plants. This direction has been devoted to many works in various regions of our country.

Very interesting article Matveeva A.V. "An energy efficient house with a system of solar hot water supply [2]. The article by Matveeva AV is devoted to the project "Energy-efficient house", which is heated by a solar water heating installation. This makes it possible to reduce the energy consumption for heating by at least 30%; reduces costs and construction time by (25-30%), reduces the level of power in operation with low power consumption. Solar energy is a renewable and inexhaustible source of energy, in the future, in order for this source to be able to replace organic fuels or nuclear fuel in electricity generation, a technological breakthrough will be required.

Biomass energy is the energy released by wood, plant and organic waste (garbage, livestock and poultry waste). The final products of biomass energy are biogas and pure fertilizers. The biomass energy can be converted into technically convenient fuels.

The article "Production and use of biomass" [3], is devoted to the forest resources of Russia, which constitute a huge potential for the use of NRME. The articles of Hakobyan VB are devoted to the use of hydrogen to produce biofuel for transport, rocket and space technology. To more fully involve technical bioenergy in the country's energy balance, it is necessary to create special types of energy biomass, develop new technologies and build efficient equipment.

At present, there is a revival of interest in the creation and use of small hydropower plants. They are increasingly spread on a new, higher technical basis, with full automation of their work.

Tidal energy is the energy obtained from the tides and outflows of the oceans, seas and rivers. Available for use potential of tides in the European part of Russia is estimated at 40 million mW, and in the Far East - at 170 million MW.

The article by Lyapin V. Yu. Covers the development of three projects of PES - Kola, Mezenskaya and Tugurskaya and the work of tidal power stations.

Low-potential energy is the energy produced from the bowels of the earth, the thickness of the waters of the seas, oceans, rivers and lakes, and airflow. This direction in the development of energy has become widely used.

In the article Kuznetsova SN talk about a new concept of solving problems of using low-potential energy, as well as problems that do not allow the effective use of natural resources. Considering in general the prospects for the use of NRME, it is necessary to note the following advantages:

- there are sufficient resources of all NIEE in the country;
- there is a need for their use;
- there is an industrial production to produce the necessary equipment;
- there is a scientific and technical potential.

The braking factors are the opposite: a precarious state of the economy, difficulties with investments, problems in the legislative and regulatory framework. The analysis of the unit cost of low-power wind turbines made it possible to establish the nature of its change, depending on the capacity of the installation (Figure 1.1).

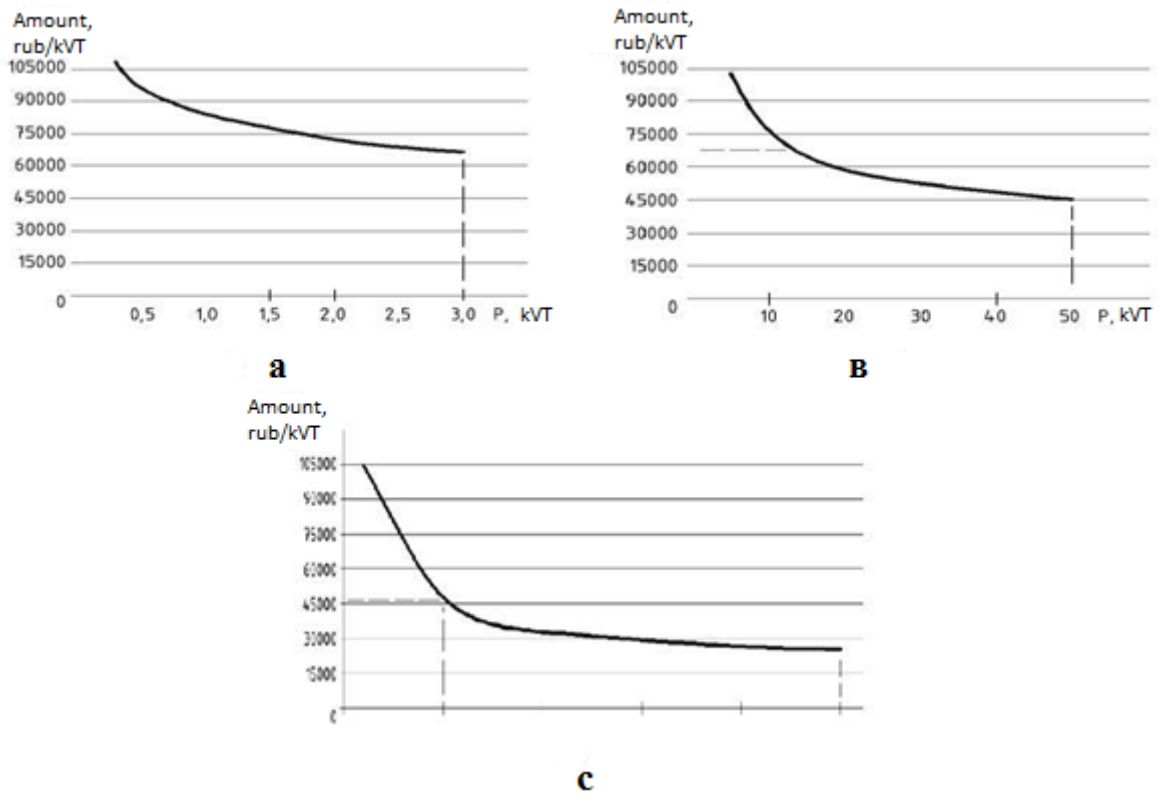


Figure 1.1 – Dependence of the unit cost of wind turbines to power

1.3 Select the type and capacity of "Wind and "Solar thermal devices"

To the Department "Aaita" Rudny industrial Institute acquired a number of innovative equipment. One of which is "wind turbine". This type of equipment is relevant and necessary for the training of energy direction. Students have the opportunity to study renewable energy in force in the territory of the University.

One of the promising directions of development of renewable energy is wind power. The use of wind energy not only helps to solve many problems of energy supply of remote objects and country houses and to gain independence from the local power organizations.

Before selecting a wind turbine it is necessary to define capacity and functionality of the device [11]. To explore the variety of wind turbines and acquainted with the climatic conditions of the region in which you plan to install the wind turbine. To determine the power output of vetroustanovki, which depends on the power Converter (inverter). The second name of output power - the peak load - the summation of the number of devices at the same time will work with the wind turbine. The output power is defined as the total capacity of wind turbines. During rare, but large consumption of electricity should choose a wind generator with a large capacity. To increase the output power, you can install multiple inverters.

Time of continuous operation is determined by the capacity of the battery mounted on the windmill. In calm weather, batteries provide the premises with electricity. The rate of charge of the battery determined by the power device, wind

speed, altitude, and topography of the territory in which a wind. The higher the power of the wind turbine, the faster the battery. At a constant consumption of electricity or light winds, you need to choose a more powerful model wind turbines. To speed battery, you should connect several generators to the wind turbine. You should not buy a lot of batteries at a weak wind force as the wind turbine will not have time to charge all batteries. If the battery is not charged until the end this leads to a rapid exit of their system, so the number of batteries should be calculated from the power consumption of all electrical appliances in the home [12].

Based on research, experiments were conducted by determining the annual average wind speed at the proposed site of the installation of wind turbines. For optimal operation of wind turbine is ensured by a wind speed of 5 m/s.

It is Better to install the wind turbine as an additional power source paired with a diesel or petrol generator. You need to test and explore possibilities of maintenance of wind turbines.

When choosing a wind turbine you need to pay attention for optimal operation of the wind turbine at average wind speed, which is typical for the study region.

Gearless wind turbines are easier to install, easily assembled and do not require additional maintenance gear despite the complexity of the installation provides more power and better quality of the wind turbine.

The cost of wind turbine depends on the following factors:

– number of blades;
– power batteries;
– power generator;
– number of inverters;
– the material of manufacture of the blades;
– the presence of reducer;
– is the nominal power of the windmill;
– type wind turbine: horizontal, vertical;
– material of the installation;
– the presence of additional components.

On the basis of studies in the University on the relevance of different types of wind turbines were selected to install a hybrid "sun – wind" with a capacity of 5 kW. Feature investigational use "Wind" is:

– the possibility of building in the conditions of remoteness from the existing engineering networks;
– reducing the burden on city engineering networks;
– reduction of operating costs;
– the impact of the installations on the exterior of buildings.

Wind energy cadastre is a set of wind characteristics, allowing to identify the energy value and to determine the possible modes of operation of wind turbines (wind turbines).

The main cadastral wind characteristics include:

– average wind speed;

– the frequency of occurrence of wind speeds;
– the frequency of occurrence of wind directions;
– the maximum wind speed;
– wind energy resources of the area.

To select a specific type of wind turbine for installation on a "Training ground" of the University was conducted the pilot study, which defined the following parameters:

– average wind speed;
– the power of the wind flow;
– the frequency of occurrence of wind speed; maximum wind speed.

On the basis of experimental studies are the following. The speed and direction of wind on measurements in the University conducted and presented in (figure 1.2). All measurements on the test objects was carried out using an anemometer M-95M-2. according to the planned schedule. The measurements were carried out at intervals of 10 minutes with (9-00 to 10-00; 12-00 to 13-00; 16-00, 17-00): the measurement of wind speed; change of wind direction; the impetuosity of the wind.

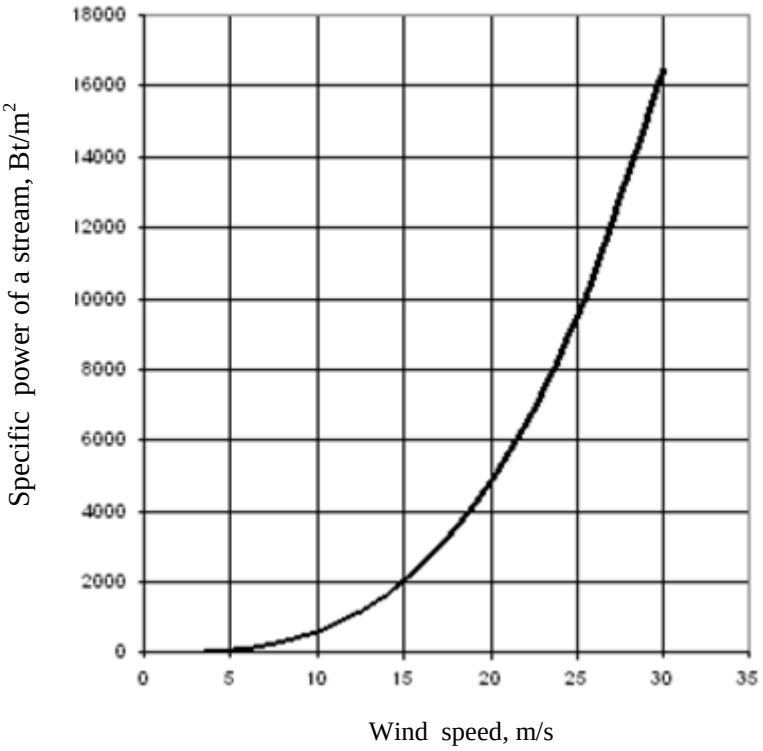


Figure 1.2 - Characteristics of the dependence of the energy of the flow on velocity

According to the obtained data, a graph of the frequency of the wind is plotted, which is presented in Fig. 1.3. The graph shows that the average speed in the territory of the Training polygon is varied from 4 to 7 m / s.

The graph shows that the average speed in the city varies between 4 and 8 m / s. The interval of working wind speeds for the generation of electrical energy is (4 ÷ 8) m / s. Consequently, the wind turbine must effectively operate within

this range and have a low start-up speed. The frequency of wind speed on the territory of the university is shown in Figure 1.4.

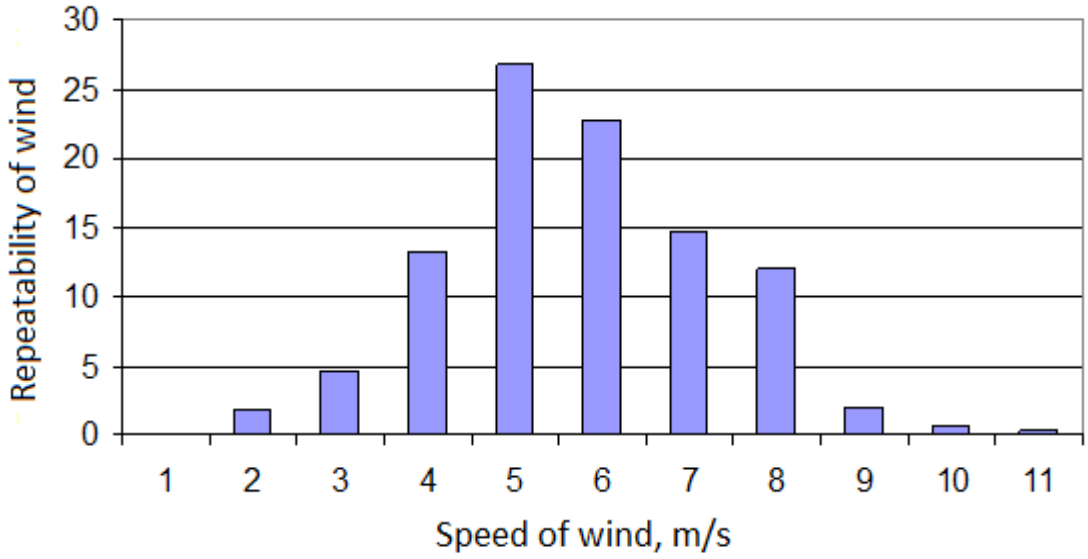


Figure 1.3 - Repeatability of wind speed in the territory of the "training ground"

In the winter months (October-March), winds of the north-western quarter can account for up to (70 ÷ 90)% of the time. The predominance of winds in these directions is overwhelming. In the warm season everything changes: the prevailing wind directions become implicit or completely different, with the decrease of the total wind intensity the volumes of possible energy production decrease.

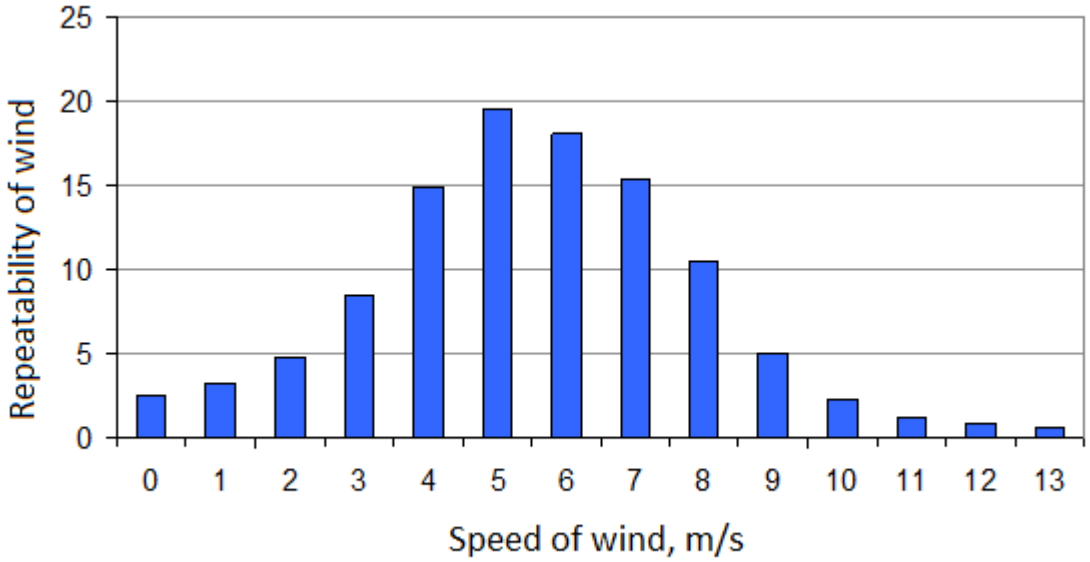


Figure 1.4 - Repeatability of wind speed in the territory of the university

According to the experimental data, a wind rose was built on the territory of the university (Figure 1.5). The wind rose clearly shows the predominance of the wind direction (north-west).

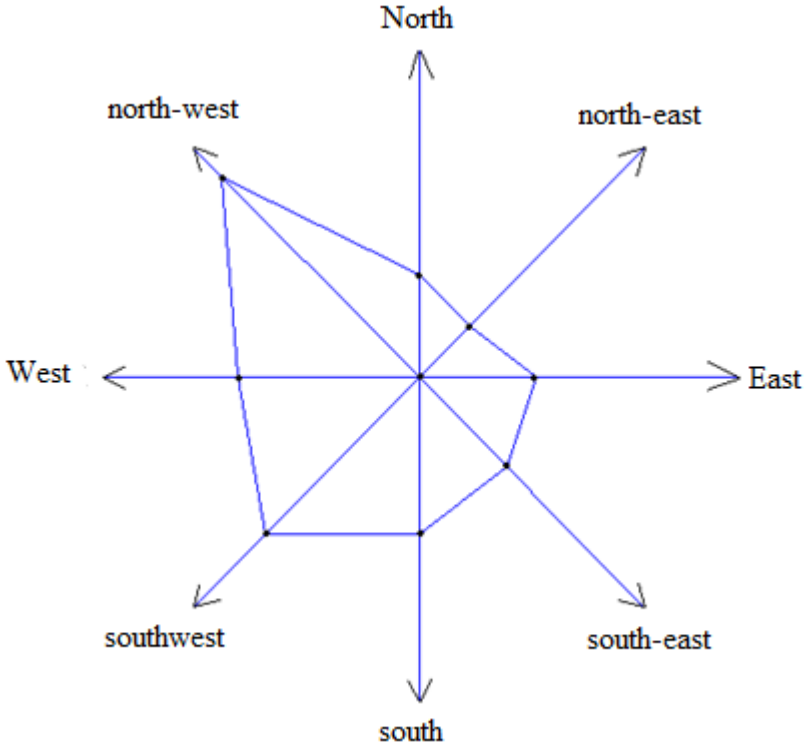


Figure 1.5 - Wind rose, obtained from experimental studies

The direction of the wind usually plays a lesser role in terms of its use. However, in landscape conditions, the winds of different points have uneven gustiness and speed. Repeatability is determined by the wind rose - a graph showing what percentage of the total time of the year the wind has this or that direction (Figure 1.5).

On the basis of all the studies carried out, a wind turbine (hybrid sun) with a power of 5 kW (Figure 1.6), installed on the "Training Ground" of the university, was selected.

The wind turbine is necessary for carrying out laboratory works on the discipline "Renewable Energy Sources", introduced into the educational process of the specialties "Power Engineering" and "Heat Power Engineering" in the amount of 2 credits. The result of the study, which is the delivery of students RGR and examination.

Solar energy is one of the safest and renewable energy sources on our planet. Its use for obtaining hot water and heat increases every year. It is assumed that by 2020, solar energy will provide one-fifth of the world's electricity consumption. To convert solar energy into thermal energy, a solar system is used - a flat or vacuum solar collector.

Solar energy is inexhaustible. The sun, solar water heaters convert solar energy into heat. Solar energy is one of the cleanest, renewable sources of energy, there is no pollution of the environment.

Conclusion: - The specific wind speed on the territory of the university is (4 - 8) m / s;

- A wind turbine of the type "Sun-Wind" hybrid with a power of 5 kW was chosen.

Figure 1.6 - Wind turbine at a training ground

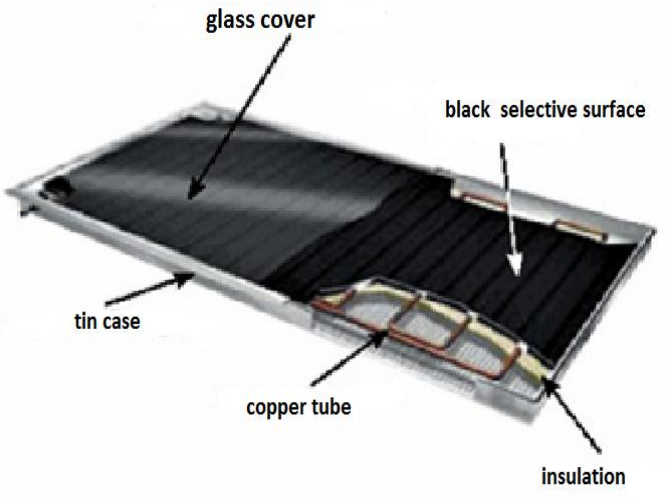
Operating a domestic solar water heater can reduce CO2 emissions in proportion to the amount of fuel saved. The greenhouse effect of carbon dioxide emissions is reduced [7].

The solar water heater converts solar energy into thermal energy, which is used to heat water. Solar water heater consists of glass vacuum collectors, heat accumulator, main frame and connected to the system of highways (Figure 1.7).

The conversion of solar energy into thermal energy is carried out through glass vacuum tubes. The heated water rises, and the cold water down. In this case, a difference in the temperature of the water in the vacuum tube is formed, which carries out water heating and circulation in the system.

Flat solar water heater-collector - a device with a flat-panel absorbing panel and a flat transparent insulation to absorb solar energy. This is a flat heat-absorbing panel - an absorber, with an area of (1 - 2) m, in which there are channels for liquid. The surface is black for better heat from the sun. The design of the solar water heater is shown in Figure 1.8.

Figure 1.7 - Vacuum solar figure solar



1.8 – The Construction of a flat collector water heating collector

Active systems use electric pumps valves and controllers to circulate since their tanks are installed above or close to the collectors.

Passive systems move ready water or coolant through the system without pumps. Passive systems have the advantage that the outage or failure of the circulating pump is not the problem. This makes passive systems generally more reliable, easier to maintain, and perhaps more durable than active systems. Passive systems are often less expensive than active systems but are also generally less efficient due to slow circulation in the system.

Active systems open loop use pumps to circulate water through the collectors. The system is efficient and lowers operating costs but is not appropriate if your water has a high mineral content or acidic, because sediments and corrosion gradually withdraw system. Active systems open loop are popular in areas with positive temperatures, or during seasonal use, though systems with vacuum tubes are able to withstand negative temperatures without the risk of damage to temperature - 40 °C.

In systems with a closed loop coolant reservoir is usually a water-glycol antifreeze. Heat exchangers transfer the heat from the primary coolant to the water, which is stored in the tanks (heat accumulators). Heat exchangers with double wall or two of a heat exchanger located in storage tank prevent contamination of the finished water. Some standards require double walls when the heat carrier is water or increased requirements of sanitary and epidemiological services [15]. Systems with closed loop are popular in areas subject to prolonged current negative temperatures, because they have good protection from freezing. System with antifreeze is more expensive to buy and to install, and antifreeze must be checked each year and replaced every few years, depending on the quality of the antifreeze and temperatures of the system. Some types of solar water heaters with vacuum tubes Thermosiphon systems (open water heaters or low pressure) thermosyphon systems work on the principle of the desire of warm water upwards, a phenomenon known as natural convection, used for water circulation through the collector and the tank. In this type of installation the tank must be located above the collector.

The author carried out extensive work on the acquisition of a photovoltaic element is open and closed at 100L and 200L, which are introduced in educational process on discipline "Renewable energy". Developed teaching materials, methodical instructions on performance of laboratory works (figure 1.9-1.10).

Figure 1.9 - Thermal solar collectors for heating closed water

Figure 1.10 - Thermal solar collectors for heating open water

Heat accumulators provide an opportunity to store heat energy and give out to the consumer as needed. This in part allows to solve the problem of temporary absence of the sun and to ensure a constant operating temperature. Heat accumulators can be installed directly on solar collectors (thermosyphons) or separately indoors. Heat accumulators installed on solar collectors.

These types of equipment are introduced into the educational process of the specialty "Power Engineering" and "Heat Power Engineering" in the form of performing laboratory work on the discipline "Renewable Energy Sources".

1.4 Introduction of renewable energy sources in the educational process

In connection with the exhibition "Expo-2017" held in the Republic of Kazakhstan, a lot of work has been done in this direction [17, 18], namely the study of "Future Energy", "Green Economy", "Green Energy":

1. The Tempus project on "Eco-engineering - ecological treatment and sustainable use of renewable resources and bio-waste" was completed from 2011 to 2014 calendar year for a total of 92 thousand euros. When implementing the Tempus project, the university acquired the following equipment:

- Wind-solar power plant with a capacity of 5 kW;
- Weather station, including a programmable module for storing information (with delivery, installation, adjustment).
- Wind generator with a power of 1 kW;
- A set of equipment for the assembly of photovoltaic kits (FEC or solar power stations of 12 volts and 220 volts);
- Heat pump;
- Solar water-heating collectors for 100L and 200L, closed and open type;
- Analyzer of energy and quality of power supply;
- Multifunctional tester of installations;

All equipment is involved in the educational process on the discipline "Renewable energy sources" in the specialties "Power engineering", "Heat power engineering" and "Vocational training" in the direction of "Electrical engineering" and radio electronics ".

2. The laboratory "Renewable Energy Sources" was established to conduct laboratory studies and research in technical fields that study the "Energy of the Future" (Figure 1.11-.1.12).

3. Developed and introduced into the educational process real models, powered from a solar installation, wind farm and heat pump:

- Power supply of main and auxiliary buildings from the wind farm and solar thermal device;

- Power supply of an energy efficient home from renewable energy sources;

- Heat supply of an energy-efficient house from thermal cliffs.

Figure 1.11 - Laboratory "Renewable energy sources"

4. On the eve of the Expo-2017, innovations in the curriculum of the specialties "Power Engineering", "Heat Power Engineering", "Vocational Training", the direction "Electrical Engineering and Radioelectronics" were introduced. The discipline "Renewable energy sources" was introduced - 2 credits - 90 hours. The result of studying the discipline is an examination in all three specialties.

5. The result of all the works carried out is the preparation of highly qualified graduates who are well versed in renewable and alternative energy, the resources of which must be used in the Republic of Kazakhstan. The credo of the department is to train highly qualified personnel who can master innovative technologies in the application and use of renewable energy. Stands introduced into the educational process for alternative energy sources enable students to master the role and significance of the "Energy of the Future".

Figure 1.12 - Renewable Energy Laboratory

1.5 Conclusions on the chapter

On the basis of the research carried out at the Department of EETIE, the following conclusions should be drawn:

- The analysis and the possibilities of using a wind turbine and a solar thermal device on the territory of the university are analyzed;
- Experimental studies were carried out to determine the speed of wind and sunshine on the territory of the university;
- a wind rose was built and the type and power of the wind turbine and the solar thermal device were selected;
- equipment for renewable energy sources was purchased and introduced into the educational process of specialties of the heat and power industry;
- The laboratory "Renewable energy sources" was created for the training of personnel in the heat and power sector;
- The specialization "Power engineering", "Heat power engineering" and "Vocational training" in the discipline "Renewable energy sources", "Wind power plants" were introduced into the educational process;
- Methodical instructions have been prepared, which highlight: the purpose of the work, the task to perform the work; theoretical information, control questions;

- Developed and implemented in the educational process of the Educational and Methodical Center for the discipline "Renewable energy sources" in the specialties "Power engineering", "Heat power engineering", "Vocational training" - the direction of electrical engineering and radio electronics;

- The implementation of the next message of the President of the Republic of Kazakhstan N.A. Nazarbayev on the highly qualified training of technical personnel;

- The university and the department provides assistance in joining the Republic of Kazakhstan in the number of 30 developed countries in the world.

2 Introduction to the educational process of the "Solar thermal device"

2.1. Study of solar panels.

The aim is to get acquainted with the concept of the solar panel and the history of its development; to study the basic structural elements of solar panels; to get acquainted with the field of application of solar panels and their shortcomings; A solar battery or a solar panel is a device consisting of a group of photocells connected to each other and made in one housing. The converted solar energy comes to the output of the battery in the form of a constant electric current. In view of the fact that one solar panel can produce a limited amount of electrical energy, systems consisting of several panels (modules) are often used (Figure 2.1).

Figure 2.1 – Solar panel

"Solar panels" — the code name devices that transform radiant energy from the sun into electrical energy. Unlike solar collectors that produce heating of the material of the heat carrier, the solar cell produces electrical energy directly. However, for the production of electricity from solar energy use and solar collectors: the collected thermal energy can be used for generating electric energy. Large solar plant using highly concentrated solar radiation as energy to actuate the thermal and other machines (steam, gas turbine, thermoelectric, etc.) are called gelioelektrostantsii (GEES).

Various devices to convert solar radiation into thermal and electrical energy, are the object of study of solar energy (from the Greek Helios. Ήλιος Helios, The Sun). The production of photovoltaic cells and solar collectors is growing rapidly in many different directions. Solar panels come in various size: from built-in calculators to occupy the roof of cars and buildings.

April 25, 1954, the company's specialists Bell Laboratories announced the creation of the first solar panels based on silicon to produce electrical current. This

discovery was made by three employees of the company — Kelvin Soltera fuller (Calvin Souther Fuller), Daryl Chapin (Daryl Chapin) and Gerald Pearson (Gerald Pearson). After 4 years, March 17, 1958, USA launched the first satellite with solar panels — Vanguard 1. After only a few months, may 15, 1958 the USSR had launched Sputnik-3, also using solar panels. Currently, work is underway to improve the efficiency of solar panels.

The principle of operation of modern solar cells based on semiconductor pn transition.

When the photon is absorbed in the region adjacent to the pn junction, creates a pair of charge carriers: the electron and the hole. One of these particles is a non-core charge and with a high probability to penetrate through the transition. As a result, due to the absorption of photon energy charges are separated in space and can't recombine. As a consequence of disturbed equilibrium charge density. When connecting the element to an external load circuit current flows.

Modules of solar panels for terrestrial applications, usually, designed for charging lead-acid batteries with a nominal voltage of 12V. Then connect 36 solar cells, and then going into the module. The resulting package is usually framed in an aluminium frame to facilitate fastening to the carrier (reference) design. Power modules solar panels can achieve (10-300) W.

The electrical parameters of these modules are reflected in the current-voltage characteristics determined at standard conditions (i.e., when the power of solar radiation equal to 1000 W/m2, temperature elements, 25°C and solar spectrum - at latitude 45°).

The point of intersection of the curve with the axis of the voltage is called open circuit voltage Vx.x., and with the axis of current - short-circuit current $I_{K.z.}$ The nominal power of the module is defined as the maximum power under standard conditions.

The voltage corresponding to maximum power is called the operating voltage V p, and the corresponding current - operating current I_P.

The value of the operating voltage for a module consisting of 36 cells is approximately equal to (16-17) (0,45-0,47 V/cell) at 25°C. This headroom voltage needed in order to compensate for the decrease in the operating voltage for the heating of solar radiation.

Temperature coefficient of open-circuit voltage for silicon is only 0.4%/degree. Temperature coefficient of current - plus 0.07 percent/degree.

The open circuit voltage of the solar module changes little when the illumination changes, while the short-circuit current are directly proportional.

The efficiency of the solar module is defined as the ratio of the maximum power of the module to the total radiation power falling on its surface under standard conditions and is equal to (15-40)%.

The power of solar battery is lower than the sum of the capacities of modules due to losses caused by difference in characteristics of the same type of module (losses misalignment). The more carefully selected modules in the battery (i.e., the smaller the difference in the characteristics of the modules), the lower the loss to the mismatch. For example, a series connection of ten modules with

variations in the characteristics of a 10% loss is about 6%, while scatter of a 5% decrease to 2%. In the case of shading of one module, or part of the elements in the module, a solar battery is a series connection there is a "hot spot effect".

"Hot spot effect" - a shaded module (or element) starts to dissipate all the power produced by the illuminated modules (or elements), it rapidly heats up and goes out of order. To eliminate this effect, a shunt diode is installed in parallel with each module (or part of it). A diode is needed when connecting more than two modules in series. A blocking diode is also connected to each line (of series-connected modules) to equalize the voltage of the rulers. All these diodes are usually located in the junction box of the module. The battery diagram is shown in Figure 2.2.

The volt-ampere curve of a solar battery has the same form as a single module. The operating point of the battery connected to the load does not always coincide with the maximum power point (especially since the position of the battery depends on the conditions of illumination and ambient temperature). Connecting such loads as, for example, an electric motor, can move the system operating point to a minimum or even zero power area (and the engine simply does not start). As a consequence, the next important component of the solar battery is voltage converters capable of coordinating a solar battery with a load. The general scheme of the solar power plant is shown in Figures (2.3 and 2.4).

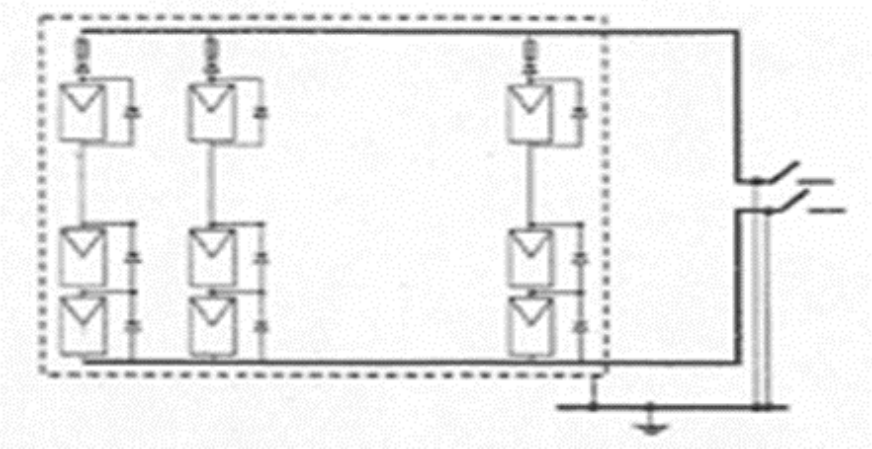


Figure 2.2 - Diode diagram in a solar battery

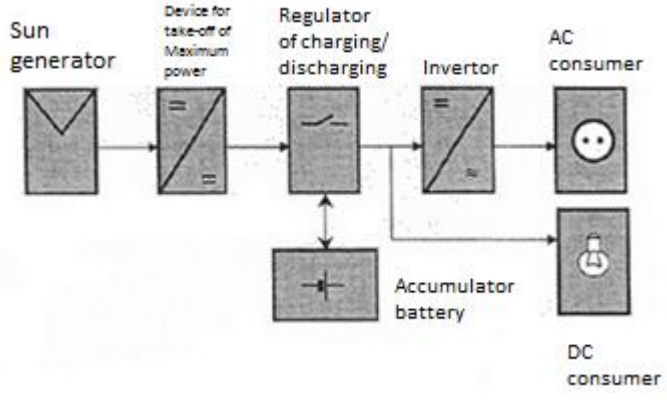


Figure 2.3 - The scheme of an autonomous solar power plant

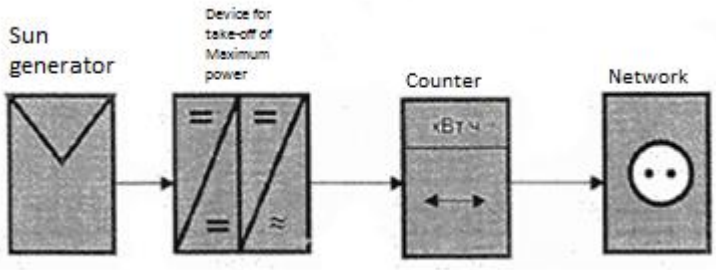


Figure 2.4 - The scheme of a solar power plant, combined with an industrial power grid

Power take-off regulators - usually, these regulators realize the principle of finding the maximum power by short periodic changes in the position of the operating point. If, however, the output power of the device increases, the position of the operating point changes in this direction at the subsequent step. Thus, the loading characteristic for selecting maximum power is continuously optimized, and it is also possible to adjust in a wide dynamic range and generate current pulses capable of charging the battery pack in low light conditions.

Batteries in the solar battery system - solar batteries are more suitable electro-batteries, as solar panels produce, and the consumer consumes electricity, which directly accumulates in the battery. The exception is solar stations for water supply, where water is consumed, and energy is stored in the potential energy of water in the water tower. More often photovoltaic systems use lead-acid batteries.

Charging and discharging regulators - To protect the battery from excessive discharge, the load must be turned off when the battery voltage falls below the trip voltage. The load must not be connected until the voltage reaches a certain value (the connection voltage). There are quite contradictory standards for these values. They depend on the design of certain batteries, the manufacturing process and the life of the batteries. In some models of regulators, an audible signal is applied, which informs the user that the power is soon turned off.

Inverters are semiconductor devices for converting a DC battery into an alternating sinusoidal shape.

The main irreversible energy losses in photocells are related to: reflection of solar radiation from the converter surface; the passage of a part of the radiation through a photocell without absorption in it; scattering by thermal vibrations of the crystal lattice of excess photon energy; photocouple recombination formed on surfaces and in the volume of a photocell; internal resistance of the converter, some other physical processes. The peculiarities of the structure of photocells cause a decrease in the performance of panels with increasing temperature. Partial dimming of the panel causes a drop in the output voltage due to losses in the unlit element, which begins to act as a parasitic load. This disadvantage can be eliminated by installing a bypass on each photocell panel. From the operating characteristics of the photovoltaic panel, it is evident that the correct selection of the load resistance is required to achieve the greatest efficiency. To do this, the

photovoltaic panels do not directly connect to the load, but use the photoelectric system controller, which ensures optimal operation of the panels. The disadvantage of solar panels is the seasonality and not the possibility of producing electricity in the dark, as well as the harmful effects on the environment in the production of structural components.

2.2 Sequential and parallel connection of solar cells.

The aim is to familiarize oneself with the operating conditions of solar batteries with a serial and parallel connection.

Photovoltaic cells are basically combined into serial-parallel connections, increasing the output power of the battery in this way. A certain number of photocells (or parallel connections of several photocells) are connected to the circuit in series, then the output voltage increases.

When the solar cells (SE) are connected in series, all the elements are located one behind the other and are connected to nearby elements by opposite poles (Figure 2.5).

To obtain an output voltage of 220 V, it is necessary to connect in parallel 10 solar cells with an output voltage of 24 V or 20 - with a voltage of 12 V. Such a connection has several disadvantages:

- unstable voltage in poor illumination;
- small power of the whole system, equal to the power of one battery.

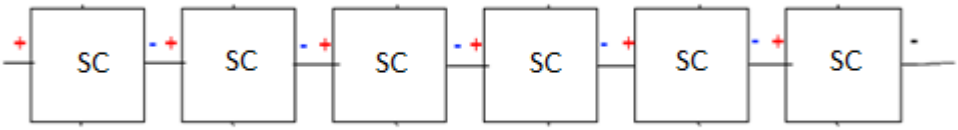


Figure 2.5 - Sequential connection of solar cells

A certain number of photocells (or successive connections of several photocells) connected in parallel, then the maximum current strength of all photocells (cells) connected in a circuit is equal to the product of the maximum current strength of one photocell or their combinations by the number of photocells. In the ideal case, the maximum power of a series-parallel connection of similar photocells is equal to the product of the maximum power of each cell by the number of photocells. The maximum power (P_{max}) of a given connection is equal to the product U_{out} and I_{max} of the entire connection.

The power of the solar panel connected in this way is less than the sum of the powers of all the modules of which it consists of the magnitude of the losses caused by the misalignment, i.e. losses caused by different characteristics of modules of the same type. In this regard, it is necessary to carefully select the modules in the solar panels, in order to minimize the loss of power caused by mismatch.

With parallel connection, all elements are connected in parallel with the same poles (figure 2.6). This connection requires the use of an additional voltage converter, it contributes to obtaining a much higher electrical power and provides stability in operation.

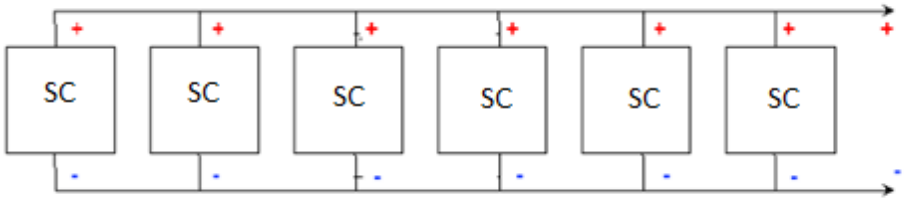


Figure 2.6-Parallel connection of solar cells

If you assemble the circuit with a series connection of batteries according to Figure 2.7:

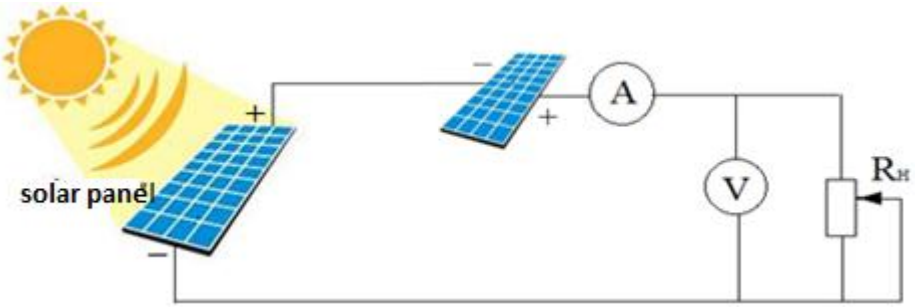


Figure 2.7 - Sequential connection of solar cells

It is possible to remove data for the construction of the current-voltage characteristic in series connection. The results of measurements are formatted in the form of table 2.1:

Table 2.1 - Sequential connection of solar panels

I, A						
U, B						
P, Вт						

The diagram with the parallel connection of the solar panels is shown in Figure 2.8:

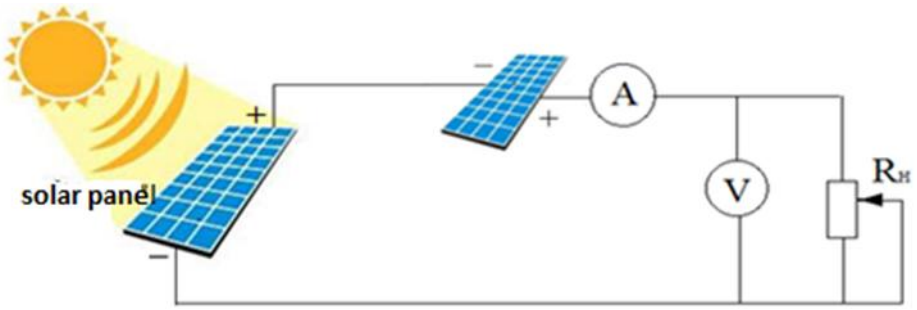


Figure 2.8 - Parallel connection of solar cells

The data for constructing the current-voltage characteristic for parallel connection are presented in Table 2.2:

Table 2.2 - Parallel connection of solar panels

I, A						
U, B						
P, Вт						

2.3 Selection of batteries for the solar panel.

The goal is to get acquainted with the criteria for choosing batteries for solar panels.

The main element in the solar panel is a rechargeable battery. With the qualitative collection of batteries in a backup or autonomous power supply system, the less energy will be spent on the cost of electricity generated by a solar power plant.

A battery is a device for accumulating energy for the purpose of its subsequent use.

The energy generated by a solar battery can be stored in various forms: chemical energy in electrochemical batteries; potential energy of water in tanks; thermal energy in thermal accumulators; kinetic energy of rotating masses or compressed air. For solar cells, electric batteries are more suitable, since solar panels produce, and the consumer consumes electricity that is directly stored in the battery. Exception - solar stations for water supply, where water is consumed, and energy is stored in the potential energy of water in the water tower.

Photovoltaic systems use lead-acid batteries. It should immediately be emphasized that batteries specially designed for solar batteries are significantly different from starter car batteries, even those that have the same technology at the basis.

The main conditions when choosing batteries are:

- resistance to cyclic operation;
- the ability to carry without consequences a deep discharge; low self-discharge of the battery;
-not critical to the violation of charging and discharging conditions;

- durability; - ease of maintenance;

-compactness and tightness (an important criterion for portable or periodically dismantled solar panels).

These requirements are fully met by batteries manufactured using the technologies "dryfit" and AGM (adsorbed electrolyte) or recombination technology. Characterized by the lack of operating costs and overlapping the range of capacities of 1-12000 A*h, which allows satisfying the requirements of all consumers. These batteries are characterized by reduced gas evolution and oxygen recombination. As a result, the electrolyte water does not electrolyse and evaporate, and such accumulators do not require replenishing the electrolyte.

In order to obtain the required operating voltage, the batteries or batteries are connected in series.

In doing so, follow certain rules:

-use only one type of batteries produced by one manufacturer;

-Exercise all batteries at the same time, without making bends from individual batteries making up the battery pack;

- do not combine batteries with a difference in the release date for more than a month in one battery;

- ensure the temperature difference of individual batteries is not more than 3 ° C.

For the sake of extending the battery life in the cyclic mode of operation in solar batteries, it is important not to allow a deep discharge. The discharge level is characterized by the depth of discharge, which is expressed as a percentage of the nominal capacity of the battery. Figure 2.9 shows the dependence of the battery capacity on the number of spent cycles at different discharge depths. The operation of batteries with a deep discharge leads to frequent replacement and to a rise in the cost of the system. The depth of discharge of solar batteries is limited to 30-40%, which is achieved by switching off the load (or reducing power) or by using larger batteries.

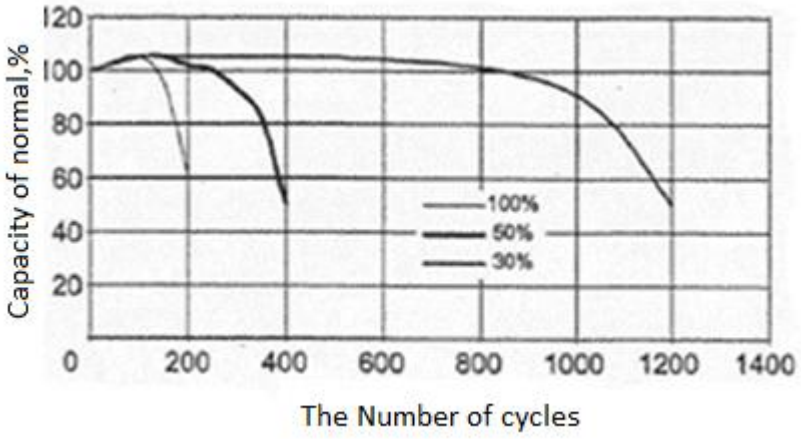


Figure 2.9 - Dependence of the battery capacity on the number of spent cycles for different depths of discharge

2.4 The choice of controls charge and discharge of batteries for solar panel.

The aim is to study regulators charge and discharge of batteries for solar panels.

The cost of the charge controller is not higher than 5% of the cost of the entire system (however, quality charge controllers depends on how often you have to change the battery). To protect the battery from excessive discharge, the load should be disconnected when the battery voltage falls below the voltage cut-off. The load should not be connected until the voltage increases to a certain value (voltage connection). There are somewhat contradictory standards of these values. They depend on the design of certain battery production process and service life of batteries. In some models of regulators applied sound signal, which informs the user of imminent power failure. To protect the battery from overcharging it is necessary to limit the charging current when voltage is reached the charging is complete. The voltage will start to decrease until it reaches another threshold, called the voltage of resuming charge. Small solar power plants have a tendency to over-consumption of energy (not to recharge) as a result, it is allowed to recharge, and thus it is necessary to apply a high voltage of charge completion. There are three ways of charge of lead-acid batteries. When charging from the solar cells, the most suitable method with two-stage charging cycle (figure 2.10).

Backup (compensation), charge batteries.

After the final charge of the battery, it is recommended to apply for her current backup (compensation) float charge. The magnitude of this current is typically 1-2% of full battery capacity. This additional third stage of the battery complicates the design of the charge regulator.

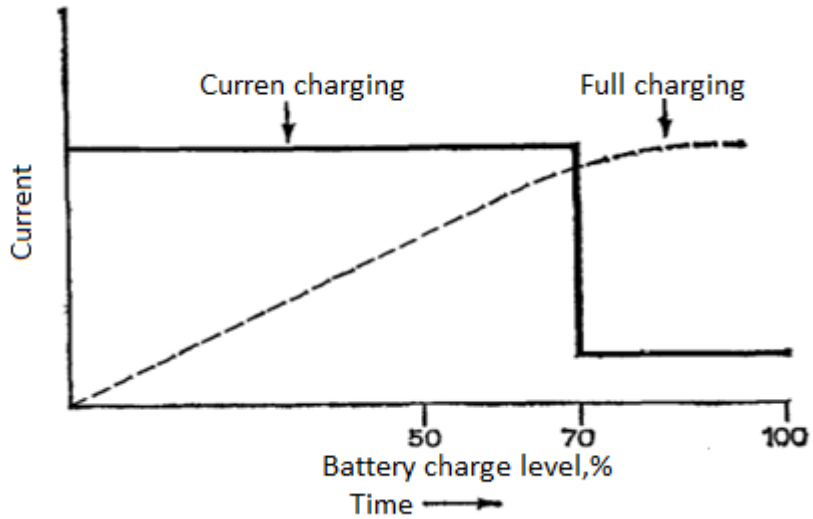


Figure 2.10 – method of charge of lead-acid batteries two-stage charging cycle

Get out of the situation it is possible, by combining the second and third stages of the charge, using as the ultimate power or backup battery charging

current is the same current, the value of which is 2% of the battery capacity. This simplifies the controller design and increases its reliability.

For normal operation of the charge controller that meets the requirements listed above to the charging current, it is necessary to have data on the degree of charge of the battery at any point in time.

Fortunately, the battery itself gives a clue to the solution of this problem: there is a securely established relationship between amount stored in the battery charge and voltage on it. As can be seen from figure 2.11 the relation is always linear.

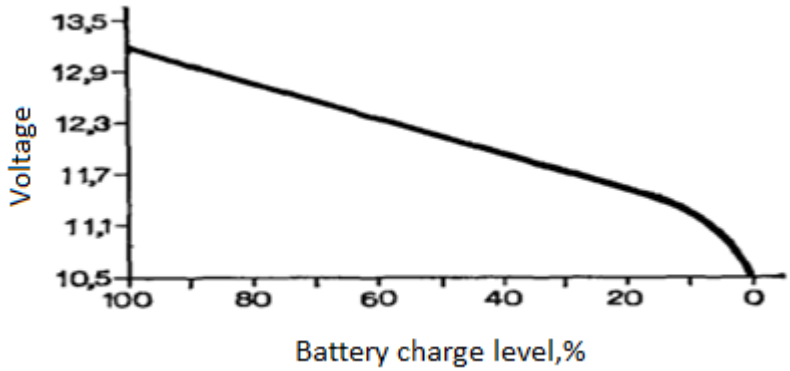


Figure 2.11–a Linear relationship of the quantity stored in the battery charge and voltage

We are interested in the area of the charge is in the range of (70-80) % from full charge. That's when the achievement of such state of charge, starts outgassing and it is necessary to change the charging current. For 12-volt battery at this point, the voltage is 12.6 V. a Fully charged battery develops voltage of 13.2 V.

Determining the voltage on the battery, you can adjust charging current. When the voltage is below 12.6 V, the battery cells contain less than 80% charge and the controller gives full charging current.

When the voltage is above 12.6 V, it is necessary to reduce the charging current to the feed current.

The voltage on the battery watching a special device (a comparator), which represents not that other, as a conventional amplifier with very high gain. Indeed, the comparator included in the circuit shown in figure 2.12, can be used as operational amplifier.

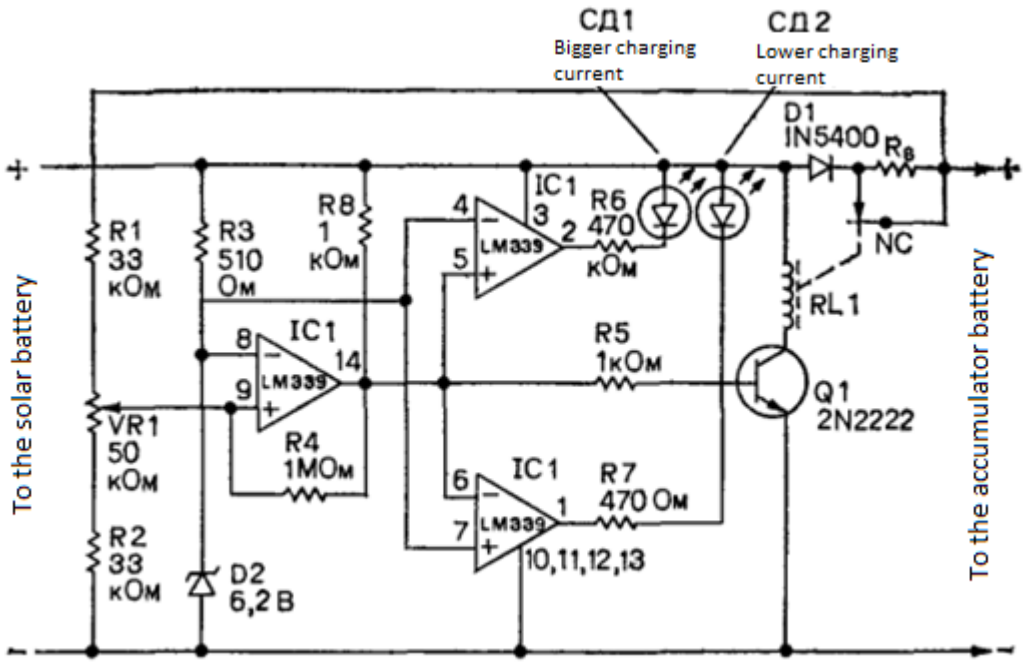


Figure 2.12–the Comparator included in the circuit

Comparator compares two voltage - measured and a reference applied to its inputs. The inverting input of the comparator (-) is fed a reference voltage from Zener diode D2. This voltage sets the trigger level of the device.

The battery voltage is divided by resistors R1 and R2 so that it is approximately equal to the voltage stabilization diode D2. The voltage divided by resistors is supplied to the not inverting input (+) of the comparator with the potentiometer to fine-tune the switching threshold.

If the battery voltage is reduced so that the signal on the not inverting input drops below the limit defined by the diode D2, the comparator output will set a negative voltage. If the battery voltage rises above the reference, the comparator output will be set positive voltage. Switching the sign of the voltage at the output of the comparator and will provide the necessary regulation of the charging current.

The charging current is regulated by the solenoid. The relay is driven by transistor QI through the output voltage of the comparator. The negative voltage at the output of the comparator indicates that the battery is discharged and requires charging current (the transistor Q1 is closed). Consequently, the collector current is zero and the relay is off.

The normally closed contacts of the relay shunt tomography significant resistor Rs. When the relay is off, the resistor removed from the circuit and full current from the solar cells is supplied to the battery.

With the increase in charge increases the voltage at the battery. The evolution of gas starts when the voltage reaches 12.6 V. the Comparator is configured to this level, switches (on the output of the comparator is a plus). Transistor opens and the current collector includes a relay. Relay contacts, shuntirovanii resistor Rs, open. The charging current from the solar cells needs to

overcome the resistance of the limiting resistor. The value of this resistor is chosen such that the charging current was 2% of battery capacity. Table 2.3 presents values of Rs, depending on battery capacity.

Table 2.3 - values of Rs, depending on capacity

Battery capacity, A*ч	Charge current, A	Reserve charge current, A	Resistance Rs, Ом	Dispersed Rs Power, Вт
5	1,0	0,1	23	0,25
10	2,0	0,2	12	0,50
15	3,0	0,3	8,7	0,80
25	5,0	0,5	4,6	1,15
50	10	1	2,3	2,3
75	15	1,5	1,5	3,4
100	20	2	1,2	4,8
150	30	3	0,7	6,3

Close to the voltage shift of the comparator there is some uncertainty. When the voltage on the battery to 12.6 V, exceeds the threshold will change the output voltage of the comparator will trigger the relay and will decrease the charging current.

The output voltage of the battery depends on the charge and other factors, is a decrease in voltage after turning off a large charging current.

The comparator will switch back and restored the regime of large charging current. Since the voltage on the battery is very close to 12.6 V, the sharp increase of current will definitely cause the surge voltage to a level higher than 12.6 V. As a result, the relay will turn off again.

Will switch the comparator back and forth close to the triggering voltage. To avoid this undesirable effect, called "yaw" in the amplifier introduces a small positive feedback using a resistor hysteresis creates a dead zone.

In the presence of hysteresis for the comparator trip requires a greater voltage change than before. The comparator switches at 12.6 V to return to the original condition the voltage at the battery should drop to 12.5 V. The oscillation effect is eliminated.

Series connection of the diode D1 in the charging circuit prevents the battery from discharging through the solar cells in the dark (at night). This diode also prevents the power consumption of the charge controller from the battery. The regulator is fully powered by solar cells.

2.5 Selection of the system controller for the solar panel.

The aim is to study the system controller for solar panels.

In powerful solar cells, the charging and discharging control functions are assumed by the system controller (controlling the whole system). The device is connected to a computer.

In modern systems, the charge controller costs between the solar battery and the batteries. The main task is to normalize the voltage generated by the photocell panels to the voltage necessary to charge the batteries taking into account their current state, including disconnecting them from the photocells when fully charged in order to avoid overcharging. Some models of charge controllers prevent overcharging only by voltage, but not by current. Weaker batteries connected to an excessively powerful photovoltaic transducer block and a too powerful charge controller can "boil over" and fail because of too much charging current. It is possible at the beginning of charging very discharged batteries when, in the absence of special current limiters, they are able to easily "absorb" large currents that cause overheating and increased gas evolution, which shortens the service life, and can cause explosion and fire. Controllers have the ability to specify the capacity of the battery pack or direct indication of the maximum charging current.

On / Off. - is a prismitive and cheap kind of controllers. When the limit voltage is reached, it disconnects the solar panels from the batteries, and the charge stops. In fact, the battery still does not have time to fully charge, it is necessary to maintain the maximum voltage for some time. Such regular undercharges negatively affect the batteries, greatly reduces their working life. These controllers are not recommended.

PWM controllers. The controller for solar cells works by the technology of pulse-width modulation. It stops the charge of the battery without shorting the solar modules and allowing you to gain 100% of the charge level. Quite cost-effective and efficient devices should be used in regions where the activity of the sun is high. Installed in systems with low power (up to 2 kW), where charging of a small capacity battery is required.

MPRT-controllers. The principle of operation of these devices is based on controlling the maximum energy peaks. The controller is more expensive than other models, more efficient in operation and allows to significantly reduce the payback period of the solar station. These regulators are "poured" into the battery approximately (25-30%) more energy than other devices. This is due to their working algorithm. It is based on tracking the point of maximum power and converting the voltage of photomodules to a lower one, but having a greater current strength. Power with this transformation does not change. To maintain the charge of the battery, the solar panels must supply a voltage higher than that of the batteries. The efficiency of these controllers is about 95%.

The most common controllers, designed for a current of 10, 20 A, sometimes 30 A. More powerful controllers are less common. It is possible to combine several not very powerful controllers in parallel, connecting each of them to their group of photovoltaic panels. The scheme has some disadvantages, but in some situations it is quite acceptable. Specific controller models may have features that do not allow such a connection. Such a combination can negate all

the advantages of controllers with MPPT and intelligent controllers that change the charge mode as the battery is charging. It is better to have a power reserve of a charge controller than to combine several low-power controllers (Figure 2.13).

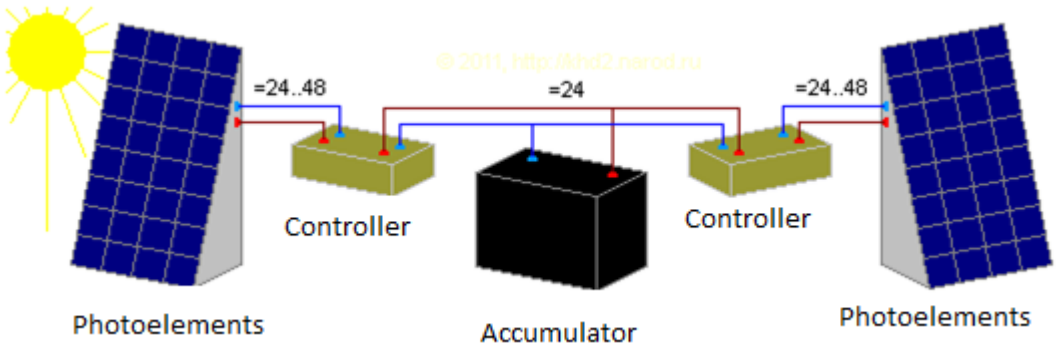


Figure 2.13 - Connection diagram of controllers to solar panels and battery

Solar battery charge controller should be chosen carefully considering two parameters:

1. Input voltage. The maximum possible voltage for the controller should be approximately 20% higher than the "idling" voltage of the solar panel. This margin of safety is necessary because:

- manufacturers often overestimate the performance parameters of their products;

- Due to increased activity of the sun, the voltage of the solar panels is higher than that stated in the documentation).

2. Rated current. For the PWM controller, this parameter must be at least 10% higher than the short-circuit current of the solar panel. The MPPT controller is selected by power. This parameter must not be lower than the product of the output current of the regulator and the system voltage. And the value of the system voltage should be taken for discharged batteries. To the obtained value it is necessary to add approximately 20% of the power reserve for periods with high solar activity.

Do not try to save, and neglect the "margin of safety", since at high insolation this can lead to the failure of the entire system, but there is no need to lay excessive reserves.

Additional features of the charge controllers include: modern controllers for solar cells are very reliable and have several degrees of protection:

- implement protection against incorrect polarity of connection;
- protection against short circuits at the input;
- protection against short circuits in loads;
- protection from overheating;
- Protection of loads from input overvoltages;
- protection from lightning discharges;
- schemes for preventing night discharges of batteries;
- electronic fuses.

To facilitate the use and monitoring of system parameters, controllers are equipped with displays. The display shows all information about the status of the battery and heliostation. For example, the level of charge and voltage of the batteries, the current of the photomodules, the charging current, the current in the load circuit, and the given / accumulated ampere hours. Also, a warning appears on the screen to reduce the charge and soon disconnect the power supply to the load.

Some controllers have timers that allow you to activate night mode. There are also models that are able to simultaneously control two independent batteries (usually in their name there is a prefix "Duo"). More advanced regulators can transmit excess energy (say, to the heater). Also, controllers are available, which can be connected to a computer for monitoring and controlling the system.

2.6 Selection of an inverter for a solar thermal device

The aim is to study and select inverters for solar panels; A solar generator can produce only a direct current. There are many consumers using direct current (battery charging, lighting, radio equipment, etc.), but consumers of AC voltage 220V or less. To convert the DC battery to an alternating sinusoidal shape, you need an inverter.

Inverters - semiconductor devices. There are two types: inverters for autonomous solar array systems; inverters for network use.

The output stage for both types is similar in many respects, but the main difference in the control scheme. The first type has a frequency generator, and the second should work in synchronism with the industrial network (and as the frequency generator uses the network itself). For all types of key parameter - efficiency (which should be more than 90%). The output voltage of autonomous inverters, as a rule, is 220V (50/60 Hz), and in inverters with a power (10-100) kW it is possible to obtain a three-phase voltage of 380V. All the autonomous inverters transform the direct current of the batteries. As a result, the input voltage is selected from the 12, 24, 48 and 120V series. The higher the input voltage, the simpler the inverter and the higher its efficiency.

There are several types of inverters for solar panels. They are classified according to the shape of the output voltage signal, which can be:

- sinusoidal;
- rectangular;
- pseudo-sinusoidal.

The waveform is the most important indicator affecting both the features of using a network inverter and its price.

Sine wave inverters. Models with a pure sinusoid generate an electrocurrent of the highest quality. The device is quite expensive. Purchase for load-sensitive loads (pumps, boilers, refrigerators, air conditioners). The high price of the device is justified, just as an inverter with a clean sine will protect the expensive equipment from failure with electric plugs.

Inverters with a rectangular signal are the cheapest and available devices. Use for connecting lighting: they do not protect the load from power surges; Most household appliances simply do not work on the voltage of a rectangular shape.

Inverters with a pseudo-sinusoid represent a kind of compromise solution between rectangular and sinusoidal waveforms. They are cheaper than sinus models and are quite suitable for solving the vast majority of household tasks. It is advisable not to use for sensitive and critical loads. Since the shape of their output signal is imperfect, they often cause light interference in telephones or minor "noises" in electrical equipment.

Inverters for photovoltaic systems differ in types:

– On-grid (inverter), designed for without battery photovoltaic systems connected to a public power grid;

– Stand-alone inverter (off grid) - works with connection to batteries and is used in stand-alone photovoltaic systems;

– Hybrid inverter - uses both of the above connections (Figure 2.14).

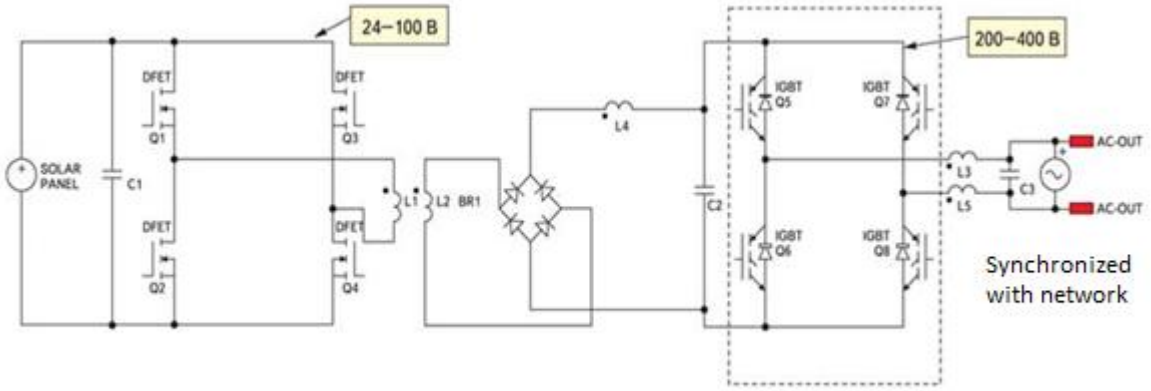


Figure 2.14- Hybrid Inverter Structure for Solar Powered Batteries

Buying inverters for solar cells can not be focused only on the output signal. There are a number of important parameters that must be taken into account to ensure the full operation of the solar station.

Input voltage. To avoid large losses in the connecting wires and not to increase the load on the inverter, it is necessary to match its power and input voltage. With a converter power of up to 600 W, it is better to select an input voltage of 12 V, with an output power of 600-1500 W, a voltage of 24 V, and with a power of more than 1500 W, 48 V.

Output. Ideal - when the nominal output power of the inverter for solar cells is equal to the total power of all loads. In practice, the choice is made simply by the most powerful load. It is necessary to take into account that in domestic appliances there are starting currents, which significantly exceed the nominal values. Select the converter must be based on peak power. At the same time, it must be remembered that if the manufacturer has not separately specified peak parameters, then most likely the power declared as nominal, in fact is peak.

In reliable and durable inverters, a rather heavy output transformer is necessarily installed. As practice shows, on average 1 kg of the product weight has

100 watts of output power. In other words, a 600-watt inverter should weigh about 6 kg.

A reliable and high-quality converter for solar cells should have several additional protective circuits. For example, forced cooling fan, high / low battery protection and short-circuit protection. A protection loop is required from the output overloads.

"Standby mode" (or "standby mode") allows you to save battery power very noticeably. After the operation is finished, the inverter does not completely shut down, but goes "on hold". The power consumption is reduced several times and is spent only to maintain the system. Power consumption without load should be about 1% of the nominal. In some models, this mode can be turned on / off manually.

If the inverter is installed in an unheated room, you should pay attention to its operating temperature range. In addition, if the specification specifies a wide operating range, this indicates the possibility of using the device not only for domestic, but also for industrial needs, is a sign of high quality.

When choosing a network inverter for solar panels, its efficiency is of great importance. This parameter should be (90-95)%, but not less. If the efficiency is below 90%, this will mean that at least a tenth of the solar energy is wasted. For solar stations, such losses are unacceptable.

2.7 The role and purpose of the Davis Vantage Pro 2 meteorological station

The goal is to acquire theoretical knowledge about the Davis Vantage Pro 2 meteorological station;

Meteorological station - a set of different instruments for meteorological measurements (weather observations).

The multifunctional meteorological complex Davis Vantage Pro 2 is designed for professional, and for domestic use has a weather forecast function that takes into account the coordinates of the location of the complex, the time of year, the current value of atmospheric pressure and its variation, wind speed and direction, temperature and humidity, . These parameters are measured by the sensors that complete the meteorological complex. The sensors of the meteorological complex are assembled into a single unit, which makes the installation of Davis Vantage Pro 2 very simple. Features Vantage Pro 2: large (150 × 90mm) display, the interval of polling the sensors from 2.5 seconds. Unique weather forecasting algorithm takes into account not only atmospheric pressure, but also temperature, humidity, wind speed and direction, precipitation amount, coordinates of the location of the meteorological complex, time of year. The graphs of the change in the meteorological parameters (24 points, different intervals) are displayed on the screen. 35 audio alerts for the functions you have selected. Computer interface with a memory capacity of 2560 records of all meteorological parameters with the indication of the date and time. The flexible configuration system allows the connection of additional sensors and modules.

Weather station Vantage Pro2 consists of a console-receiver and an integrated set of sensors (ISS).

The integrated set of sensors in the basic version includes:

- Anemometer;
- Precipitation collector;
- temperature and humidity sensors;
- cable interface or radio transmitter for communication with the console.

In the Plus version, the ISS integrates ultraviolet and solar radiation sensors.

In the version with active ventilation, the temperature and humidity sensors are enclosed in an actively ventilated casing, reducing the effect of solar radiation and prolonging the life of the sensors.

The anemometer can be installed together with the ISS or separately, using the 12-meter cable supplied or an additional cable extending up to a maximum of 73 meters. The console receives data from the ISS over a cable or radio link.

In the console are mounted sensors for determining

- pressure;
- temperature;
- humidity inside the room.

The display displays data in the form of numbers, icons and graphs (Figure 2.15). The console can be programmed with sound alerts for threshold values (too low or high temperature, too strong wind, etc.).

The kit includes fasteners for mounting the ISS and anemometer to a pipe or a vertical surface. Using additional software and the Weather Link data logger, you can connect the console directly to a personal computer, while gaining extensive monitoring of weather data, the ability to record weather data over a long period of time, and the transmission of weather parameters via the Internet.

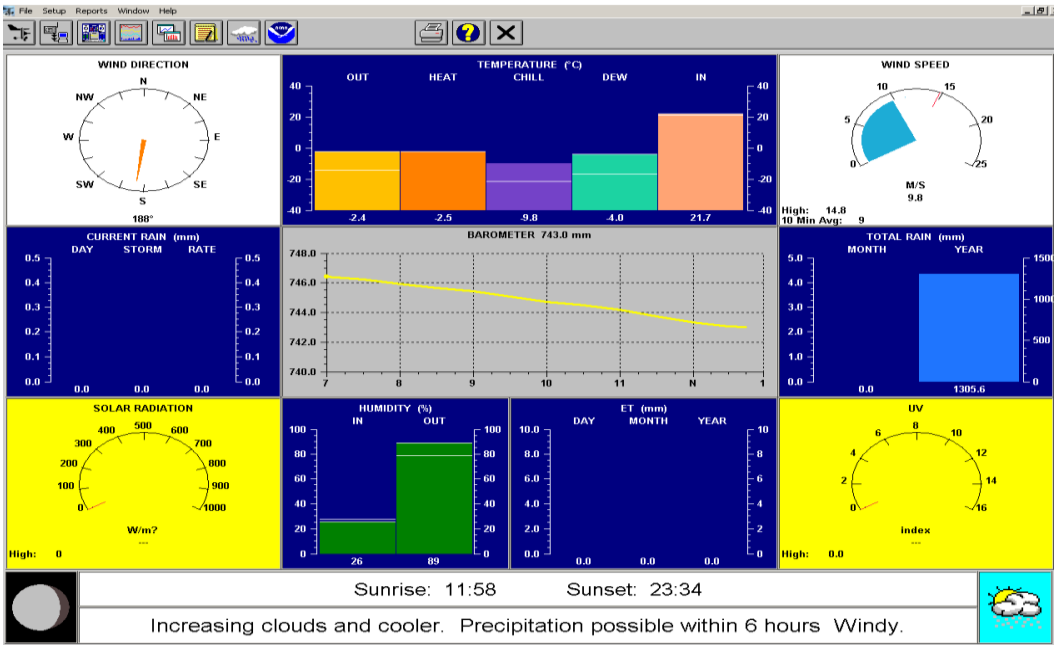


Figure 2.15 -Interface of the Weather Link program, when connecting a weather station to a computer.

The Weather Link is installed into the console and remembers weather data even when the computer is turned off. The range of the radio signal is up to 300 meters in line of sight or from 60 to 120 meters through the walls, depending on the specific conditions. You can add repeaters to increase the signal radius to 2.7 kilometers.

The multifunction display of the meteorological complex displays: atmospheric pressure; street and room temperature; street and room relative humidity; wind speed and direction; dew point temperature; number and intensity of precipitation; date and time; weather forecast; phase of the moon; time of sunrise and sunset; "Imaginary" temperature and "coolness" of the wind with an additional solar radiation sensor:

- the intensity of solar radiation;
- indicator of volatility;
- with an additional ultraviolet radiation sensor:
- a dose of ultraviolet radiation;
- Index of ultraviolet radiation.

Weather station Vantage Pro2 is designed for use in harsh climatic conditions of hot summer and frosty winter.

The EEiTE chair purchased and implemented the weather station of the following type in the educational process (Figure 2.16).

Figure 2.16 - Weather Station of the EEET Department

Figure 2.17 - Collection of information from the weather station

The weather station has the ability to take readings of 17 components. The installation is used when conducting laboratory works on the discipline "Renewable energy sources"; NIRS; when choosing a special issue of the thesis project; when passing the training and familiarization practice, etc.

2.8. Experimental temperature studies obtained from the Davis Vantage Pro meteorological station. 2.

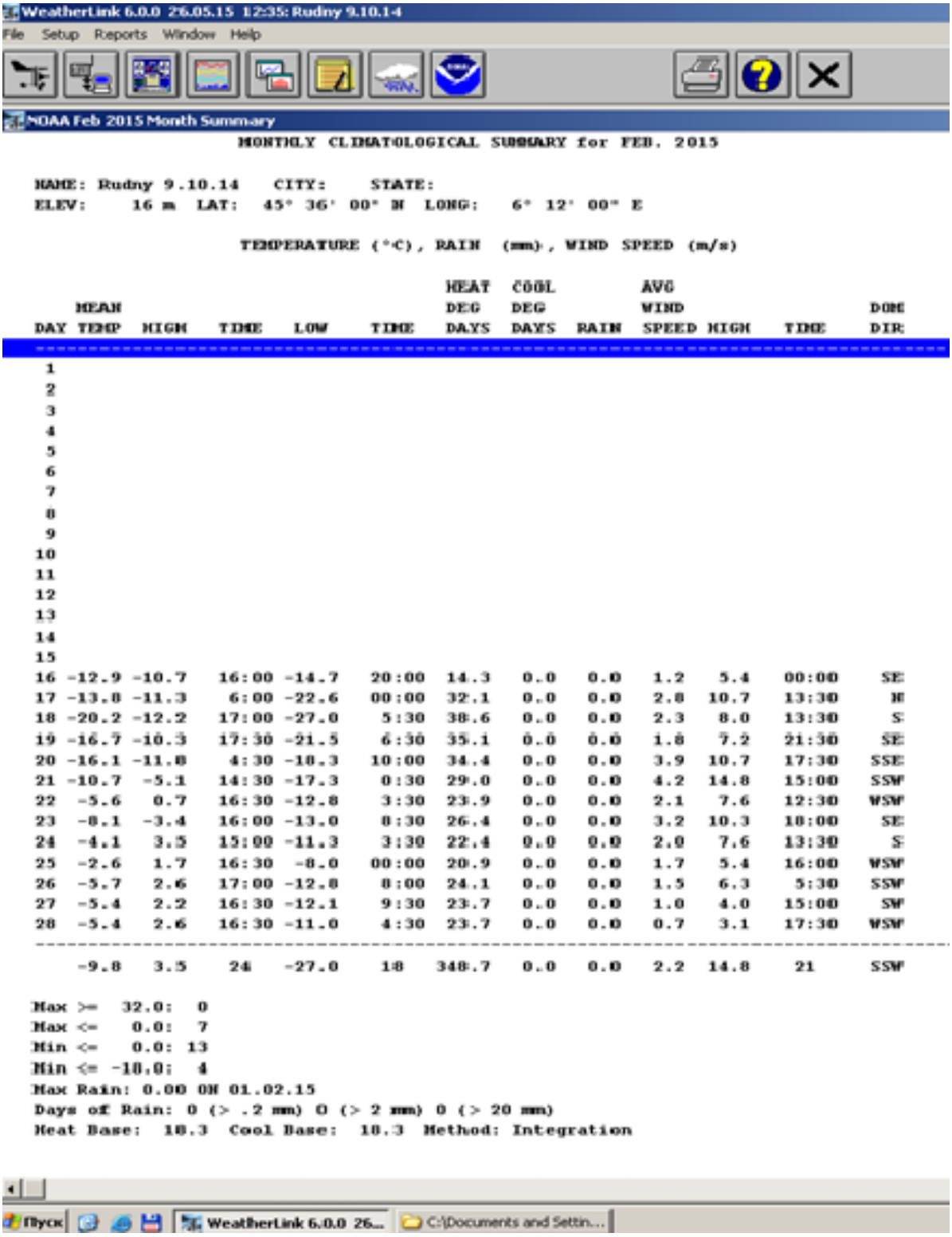
The aim is to acquire practical and theoretical knowledge in the methods of taking temperature readings from the Davis Vantage Pro 2 meteorological station and in plotting the data given;

The multifunctional meteorological complex Davis Vantage Pro 2 can be used both in professional activities and at home, and has a weather forecast function that takes into account the coordinates of the location of the complex, the time of year, the current value of atmospheric pressure and its variation, wind speed and direction, temperature and humidity, rainfall. These parameters are measured by the sensors that complete the meteorological complex.

When connecting the console directly to a personal computer, we get access to advanced functions. This makes it possible to display the graphs of the parameters of interest directly on the screen and monitor various weather conditions and parameters.

You define the time interval yourself for the last 12 hours, day, day, 3 days, week, month, year, last year. There is a function for changing the colors of the

charts for clear and accurate observation. All recorded weather conditions are saved on the console, and then, if necessary, loaded onto the PC. Figure 2.18 shows the data of the recorded weather stations for the month of May. Figure 2.19 shows a graph of the dew point plotted from the data for 3 days, as well as the weather station readings for the month of May.



WeatherLink 6.0.0 26.05.15 12:35: Rudny 9.10.14

File Setup Reports Window Help

NOAA Feb 2015 Month Summary

MONTHLY CLIMATOLOGICAL SUMMARY for FEB. 2015

NAME: Rudny 9.10.14 CITY: STATE:
ELEV: 16 m LAT: 45° 36' 00" N LONG: 6° 12' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16	-12.9	-10.7	16:00	-14.7	20:00	14.3	0.0	0.0	1.2	5.4	00:00	SE
17	-13.8	-11.3	6:00	-22.6	00:00	32.1	0.0	0.0	2.8	10.7	13:30	N
18	-20.2	-12.2	17:00	-27.0	5:30	38.6	0.0	0.0	2.3	8.0	13:30	S
19	-16.7	-10.3	17:30	-21.5	6:30	35.1	0.0	0.0	1.8	7.2	21:30	SE
20	-16.1	-11.8	4:30	-18.3	10:00	34.4	0.0	0.0	3.9	10.7	17:30	SSE
21	-10.7	-5.1	14:30	-17.3	0:30	29.0	0.0	0.0	4.2	14.8	15:00	SSW
22	-5.6	0.7	16:30	-12.8	3:30	23.9	0.0	0.0	2.1	7.6	12:30	WSW
23	-8.1	-3.4	16:00	-13.0	8:30	26.4	0.0	0.0	3.2	10.3	10:00	SE
24	-4.1	3.5	15:00	-11.3	3:30	22.4	0.0	0.0	2.0	7.6	13:30	S
25	-2.6	1.7	16:30	-8.0	00:00	20.9	0.0	0.0	1.7	5.4	16:00	WSW
26	-5.7	2.6	17:00	-12.8	8:00	24.1	0.0	0.0	1.5	6.3	5:30	SSW
27	-5.4	2.2	16:30	-12.1	9:30	23.7	0.0	0.0	1.0	4.0	15:00	SW
28	-5.4	2.6	16:30	-11.0	4:30	23.7	0.0	0.0	0.7	3.1	17:30	WSW
	-9.8	3.5	24	-27.0	18	348.7	0.0	0.0	2.2	14.8	21	SSW

Max >= 32.0: 0
Max <= 0.0: 7
Min <= 0.0: 13
Min <= -18.0: 4
Max Rain: 0.00 ON 01.02.15
Days of Rain: 0 (> .2 mm) 0 (> 2 mm) 0 (> 20 mm)
Heat Base: 18.3 Cool Base: 18.3 Method: Integration

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Figure 2.18 - The data given for the month of February.

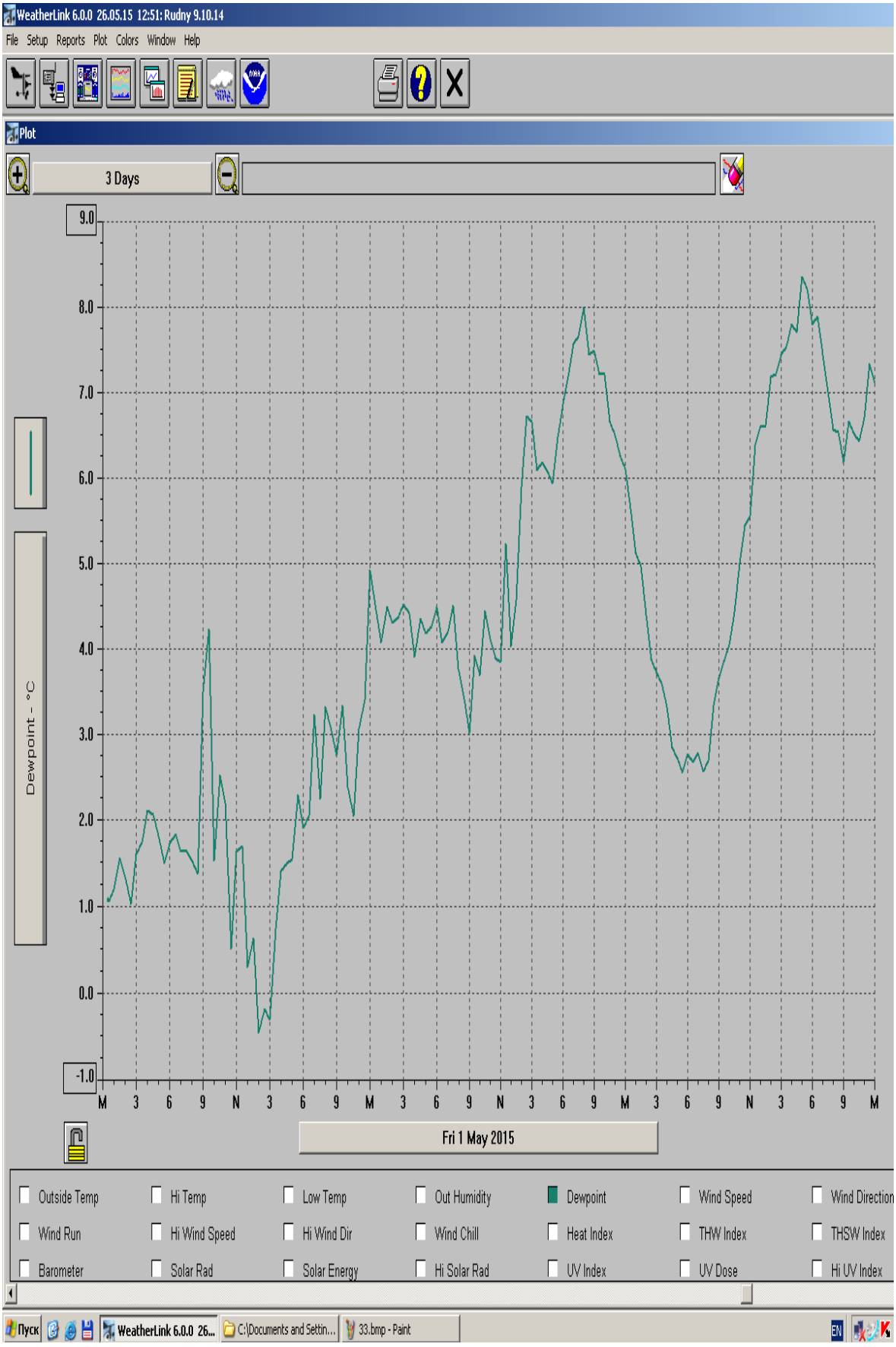
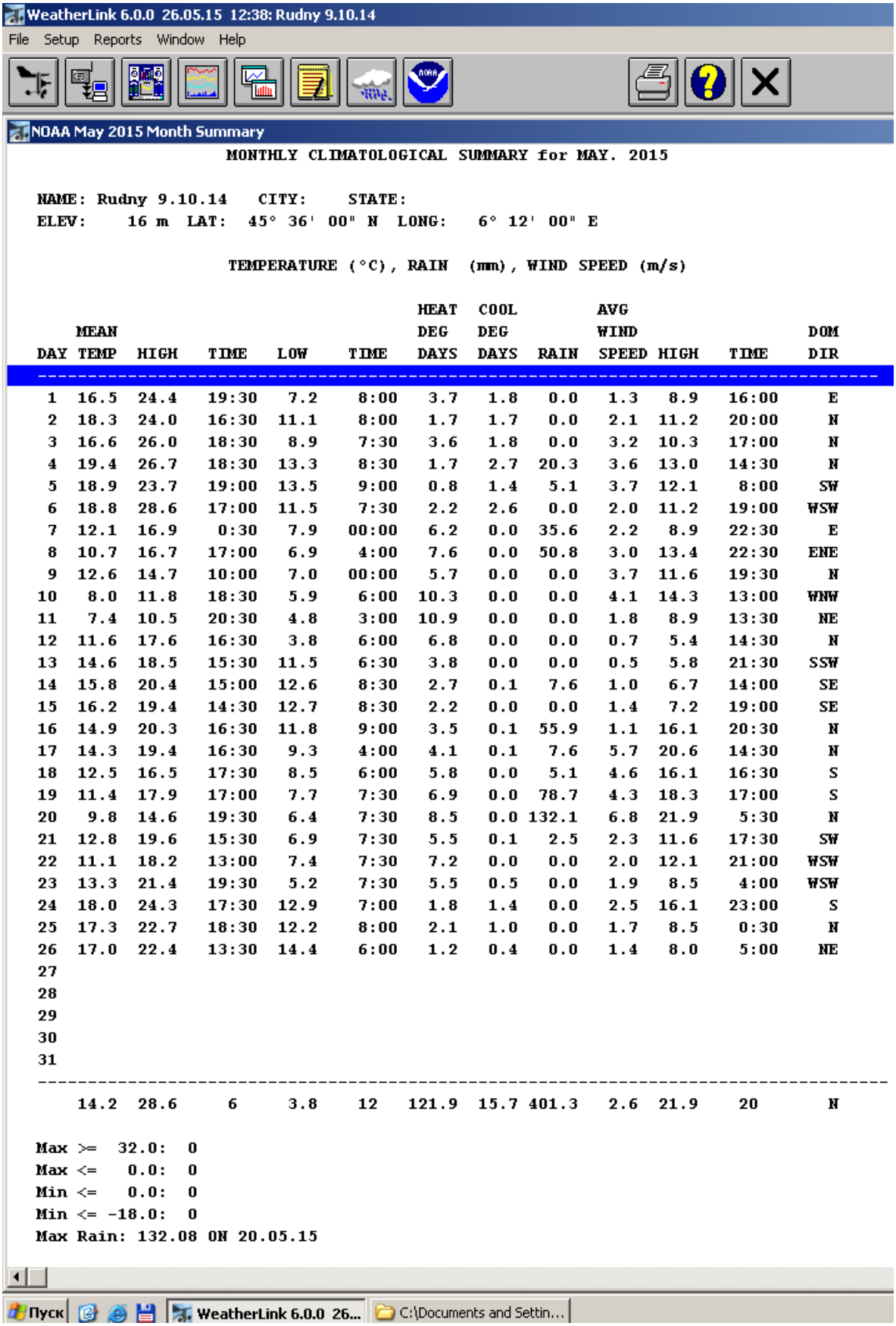


Figure 2.19 - Dew point plot constructed according to the data given for 3 days of May of the month. The above indications for one month are shown in Figure 2.20.



WeatherLink 6.0.0 26.05.15 12:38: Rudny 9.10.14

File Setup Reports Window Help

NOAA May 2015 Month Summary

MONTHLY CLIMATOLOGICAL SUMMARY for MAY. 2015

NAME: Rudny 9.10.14 CITY: STATE:
ELEV: 16 m LAT: 45° 36' 00" N LONG: 6° 12' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	16.5	24.4	19:30	7.2	8:00	3.7	1.8	0.0	1.3	8.9	16:00	E
2	18.3	24.0	16:30	11.1	8:00	1.7	1.7	0.0	2.1	11.2	20:00	N
3	16.6	26.0	18:30	8.9	7:30	3.6	1.8	0.0	3.2	10.3	17:00	N
4	19.4	26.7	18:30	13.3	8:30	1.7	2.7	20.3	3.6	13.0	14:30	N
5	18.9	23.7	19:00	13.5	9:00	0.8	1.4	5.1	3.7	12.1	8:00	SW
6	18.8	28.6	17:00	11.5	7:30	2.2	2.6	0.0	2.0	11.2	19:00	WSW
7	12.1	16.9	0:30	7.9	00:00	6.2	0.0	35.6	2.2	8.9	22:30	E
8	10.7	16.7	17:00	6.9	4:00	7.6	0.0	50.8	3.0	13.4	22:30	ENE
9	12.6	14.7	10:00	7.0	00:00	5.7	0.0	0.0	3.7	11.6	19:30	N
10	8.0	11.8	18:30	5.9	6:00	10.3	0.0	0.0	4.1	14.3	13:00	WNW
11	7.4	10.5	20:30	4.8	3:00	10.9	0.0	0.0	1.8	8.9	13:30	NE
12	11.6	17.6	16:30	3.8	6:00	6.8	0.0	0.0	0.7	5.4	14:30	N
13	14.6	18.5	15:30	11.5	6:30	3.8	0.0	0.0	0.5	5.8	21:30	SSW
14	15.8	20.4	15:00	12.6	8:30	2.7	0.1	7.6	1.0	6.7	14:00	SE
15	16.2	19.4	14:30	12.7	8:30	2.2	0.0	0.0	1.4	7.2	19:00	SE
16	14.9	20.3	16:30	11.8	9:00	3.5	0.1	55.9	1.1	16.1	20:30	N
17	14.3	19.4	16:30	9.3	4:00	4.1	0.1	7.6	5.7	20.6	14:30	N
18	12.5	16.5	17:30	8.5	6:00	5.8	0.0	5.1	4.6	16.1	16:30	S
19	11.4	17.9	17:00	7.7	7:30	6.9	0.0	78.7	4.3	18.3	17:00	S
20	9.8	14.6	19:30	6.4	7:30	8.5	0.0	132.1	6.8	21.9	5:30	N
21	12.8	19.6	15:30	6.9	7:30	5.5	0.1	2.5	2.3	11.6	17:30	SW
22	11.1	18.2	13:00	7.4	7:30	7.2	0.0	0.0	2.0	12.1	21:00	WSW
23	13.3	21.4	19:30	5.2	7:30	5.5	0.5	0.0	1.9	8.5	4:00	WSW
24	18.0	24.3	17:30	12.9	7:00	1.8	1.4	0.0	2.5	16.1	23:00	S
25	17.3	22.7	18:30	12.2	8:00	2.1	1.0	0.0	1.7	8.5	0:30	N
26	17.0	22.4	13:30	14.4	6:00	1.2	0.4	0.0	1.4	8.0	5:00	NE
27												
28												
29												
30												
31												
	14.2	28.6	6	3.8	12	121.9	15.7	401.3	2.6	21.9	20	N

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 132.08 ON 20.05.15

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Figure 2.20 - The given indications of the weather station for May month

The given graph of the outside temperature for 1 day is shown in Figure 2.21.

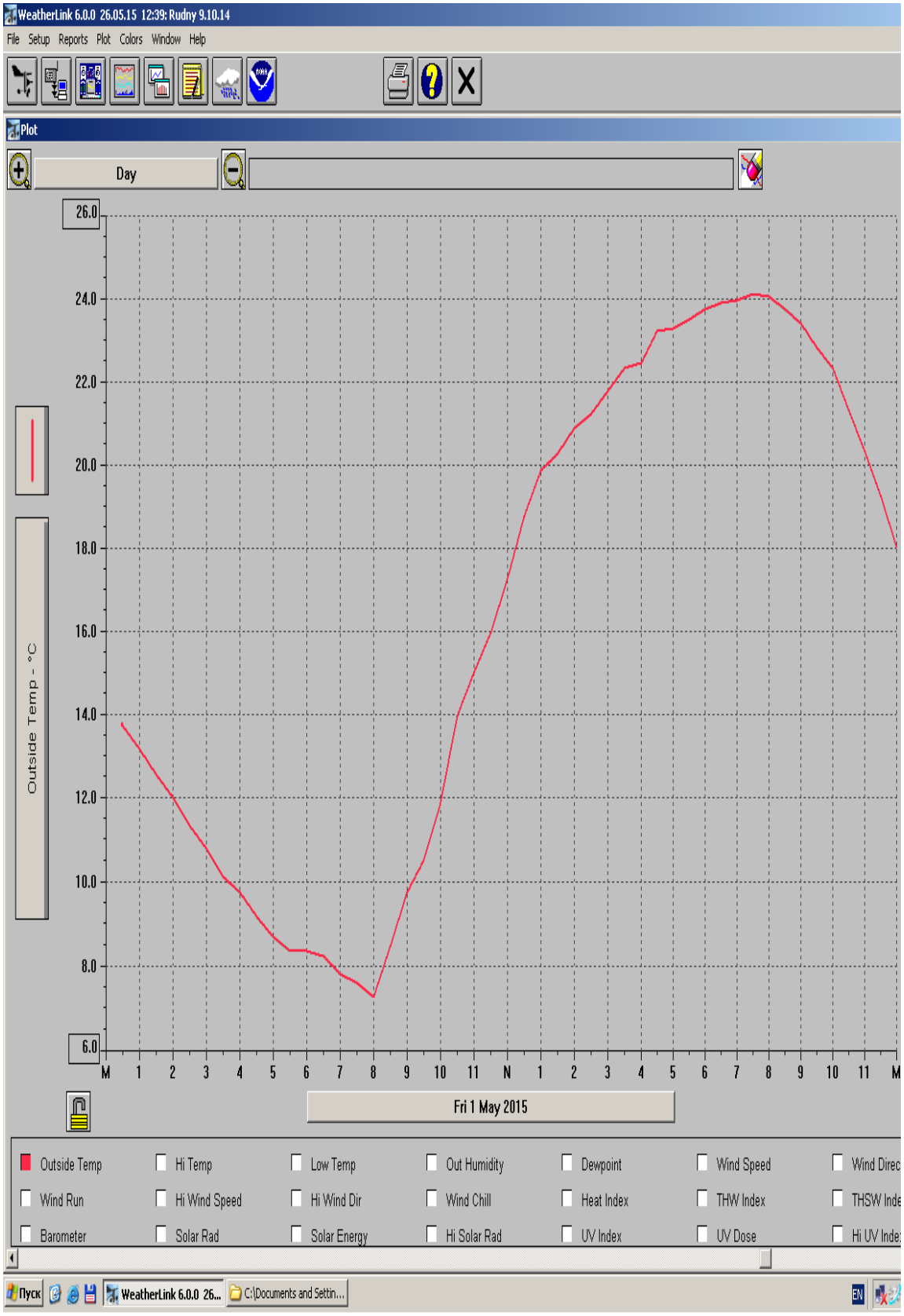


Figure 2.21 - The given graph of the outside temperature for 1 day

The given graph of the outside temperature for 3 days in Figure 2.22.

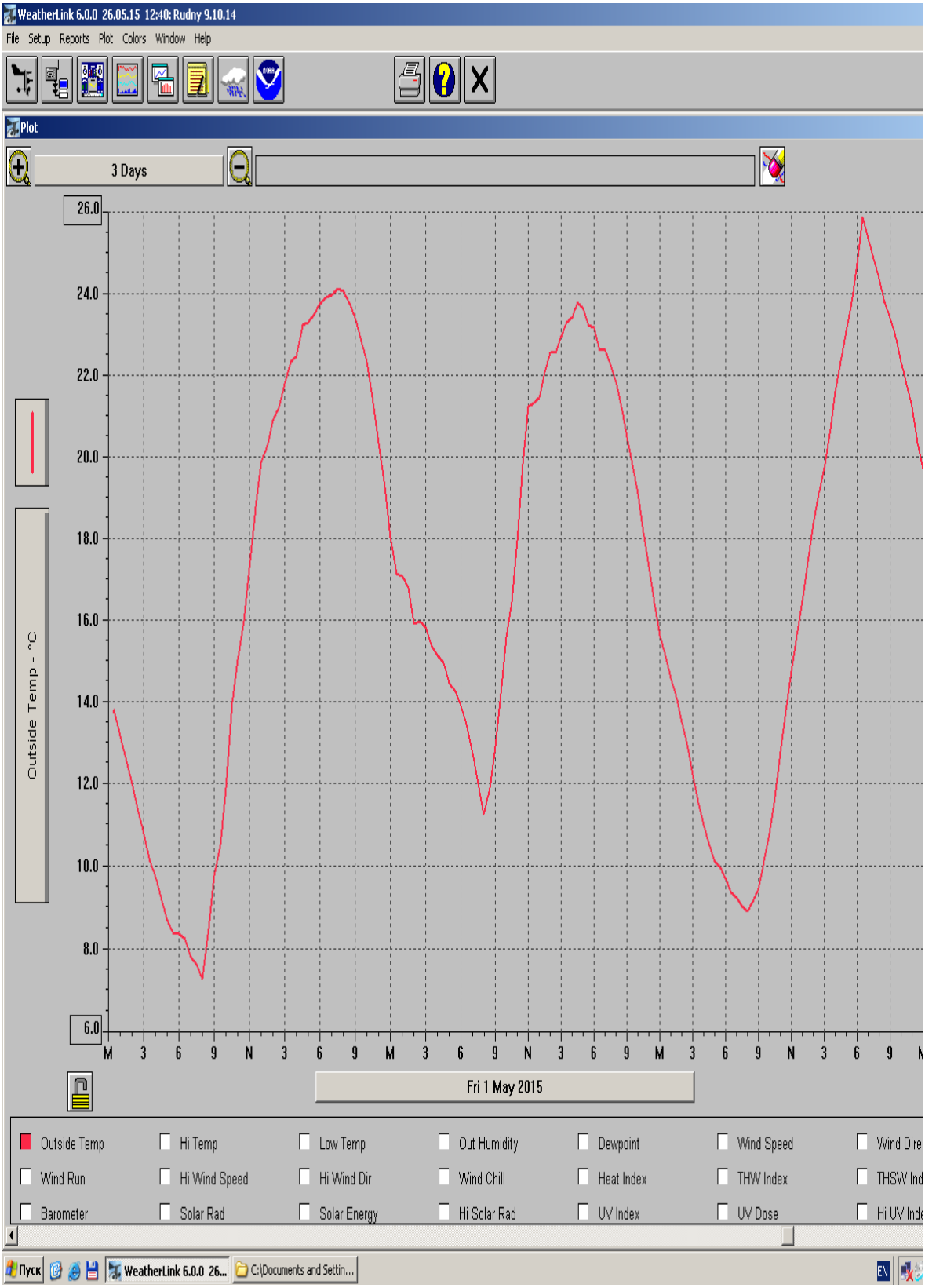


Figure 2.22 - The above graph of the outside temperature for 3 days

The given graph of the outdoor temperature for the week in Figure 2.23.

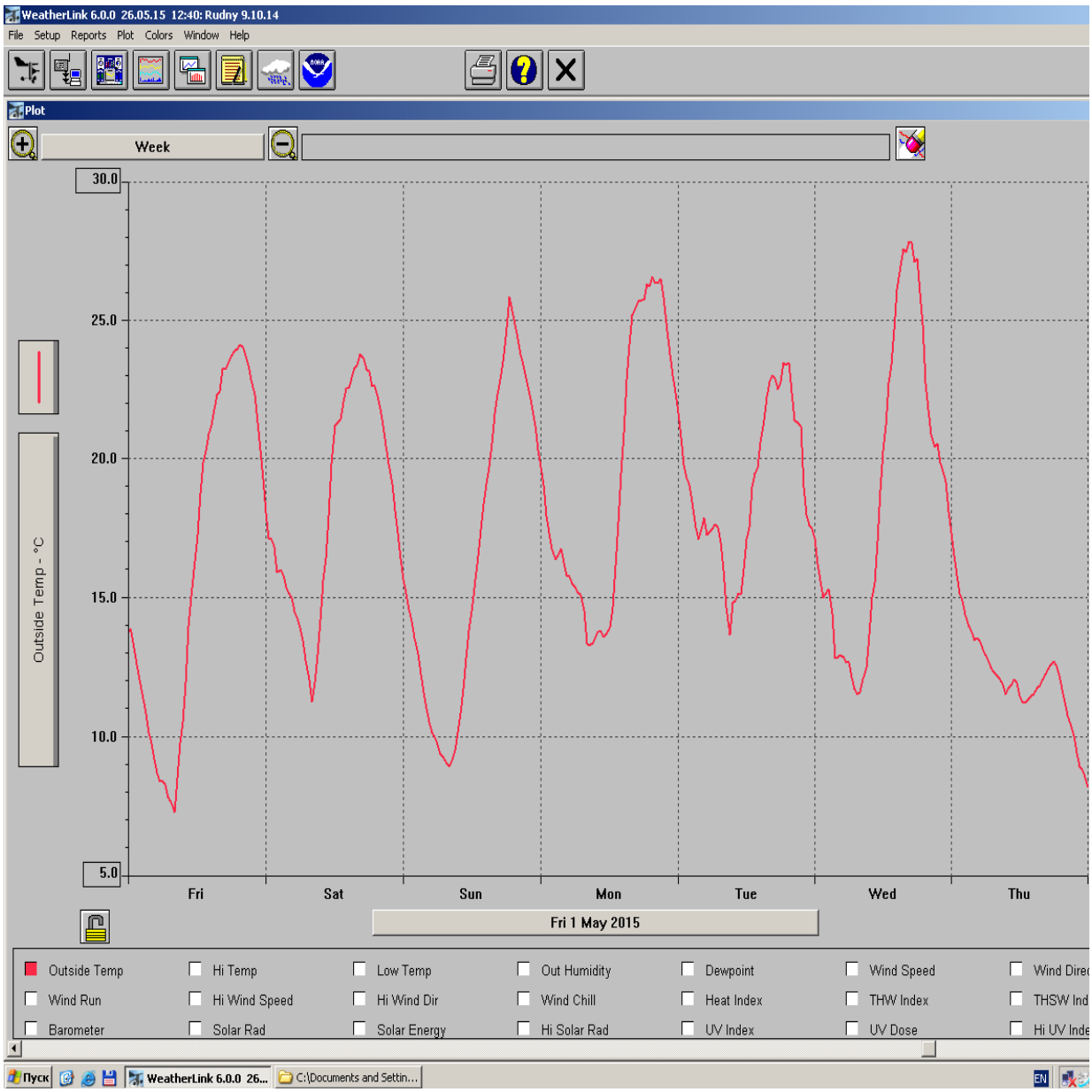
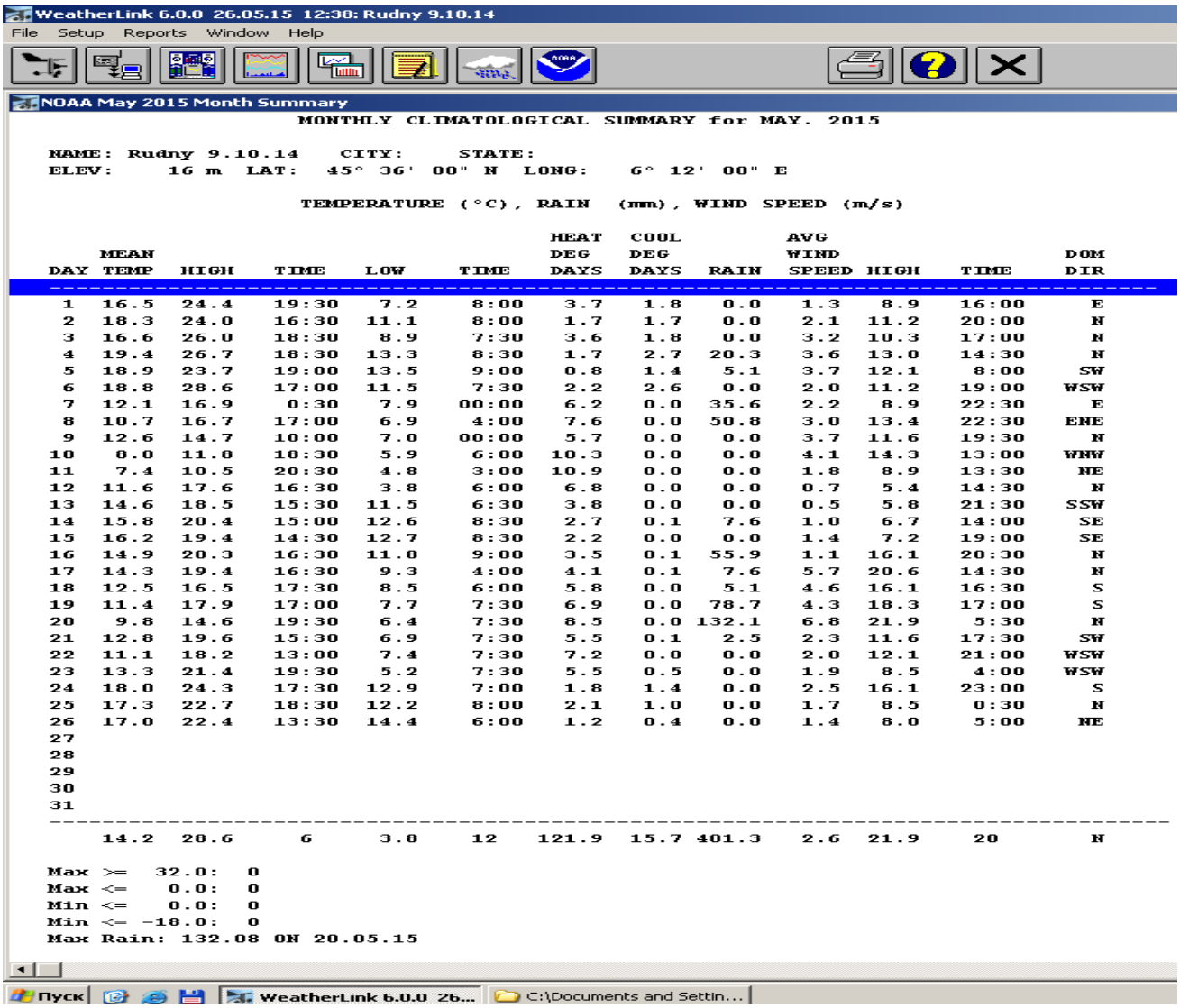


Figure 2.23 - The above graph of the outdoor temperature for the week

2.9. Removing the wind speed from the Davis Vantage Pro 2 meteorological station.

The goal is to acquire practical and theoretical knowledge in methods of taking wind speed readings from the Davis Vantage Pro 2 meteorological station and in plotting the data given (figure 2.24). The given indications of the weather station for the month of May in Figure 2.24.



MONTHLY CLIMATOLOGICAL SUMMARY for MAY. 2015

NAME: Rudny 9.10.14 CITY: STATE:
ELEV: 16 m LAT: 45° 36' 00" N LONG: 6° 12' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	16.5	24.4	19:30	7.2	8:00	3.7	1.8	0.0	1.3	8.9	16:00	E
2	18.3	24.0	16:30	11.1	8:00	1.7	1.7	0.0	2.1	11.2	20:00	N
3	16.6	26.0	18:30	8.9	7:30	3.6	1.8	0.0	3.2	10.3	17:00	N
4	19.4	26.7	18:30	13.3	8:30	1.7	2.7	20.3	3.6	13.0	14:30	N
5	18.9	23.7	19:00	13.5	9:00	0.8	1.4	5.1	3.7	12.1	8:00	SW
6	18.8	28.6	17:00	11.5	7:30	2.2	2.6	0.0	2.0	11.2	19:00	WSW
7	12.1	16.9	0:30	7.9	00:00	6.2	0.0	35.6	2.2	8.9	22:30	E
8	10.7	16.7	17:00	6.9	4:00	7.6	0.0	50.8	3.0	13.4	22:30	ENE
9	12.6	14.7	10:00	7.0	00:00	5.7	0.0	0.0	3.7	11.6	19:30	N
10	8.0	11.8	18:30	5.9	6:00	10.3	0.0	0.0	4.1	14.3	13:00	WNW
11	7.4	10.5	20:30	4.8	3:00	10.9	0.0	0.0	1.8	8.9	13:30	NE
12	11.6	17.6	16:30	3.8	6:00	6.8	0.0	0.0	0.7	5.4	14:30	N
13	14.6	18.5	15:30	11.5	6:30	3.8	0.0	0.0	0.5	5.8	21:30	SSW
14	15.8	20.4	15:00	12.6	8:30	2.7	0.1	7.6	1.0	6.7	14:00	SE
15	16.2	19.4	14:30	12.7	8:30	2.2	0.0	0.0	1.4	7.2	19:00	SE
16	14.9	20.3	16:30	11.8	9:00	3.5	0.1	55.9	1.1	16.1	20:30	N
17	14.3	19.4	16:30	9.3	4:00	4.1	0.1	7.6	5.7	20.6	14:30	N
18	12.5	16.5	17:30	8.5	6:00	5.8	0.0	5.1	4.6	16.1	16:30	S
19	11.4	17.9	17:00	7.7	7:30	6.9	0.0	78.7	4.3	18.3	17:00	S
20	9.8	14.6	19:30	6.4	7:30	8.5	0.0	132.1	6.8	21.9	5:30	N
21	12.8	19.6	15:30	6.9	7:30	5.5	0.1	2.5	2.3	11.6	17:30	SW
22	11.1	18.2	13:00	7.4	7:30	7.2	0.0	0.0	2.0	12.1	21:00	WSW
23	13.3	21.4	19:30	5.2	7:30	5.5	0.5	0.0	1.9	8.5	4:00	WSW
24	18.0	24.3	17:30	12.9	7:00	1.8	1.4	0.0	2.5	16.1	23:00	S
25	17.3	22.7	18:30	12.2	8:00	2.1	1.0	0.0	1.7	8.5	0:30	N
26	17.0	22.4	13:30	14.4	6:00	1.2	0.4	0.0	1.4	8.0	5:00	NE
27												
28												
29												
30												
31												
	14.2	28.6	6	3.8	12	121.9	15.7	401.3	2.6	21.9	20	N

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 132.08 ON 20.05.15

Figure 2.24 - The above weather station readings for May month

The given graph of wind speed for 1 day in Figure 2.25.

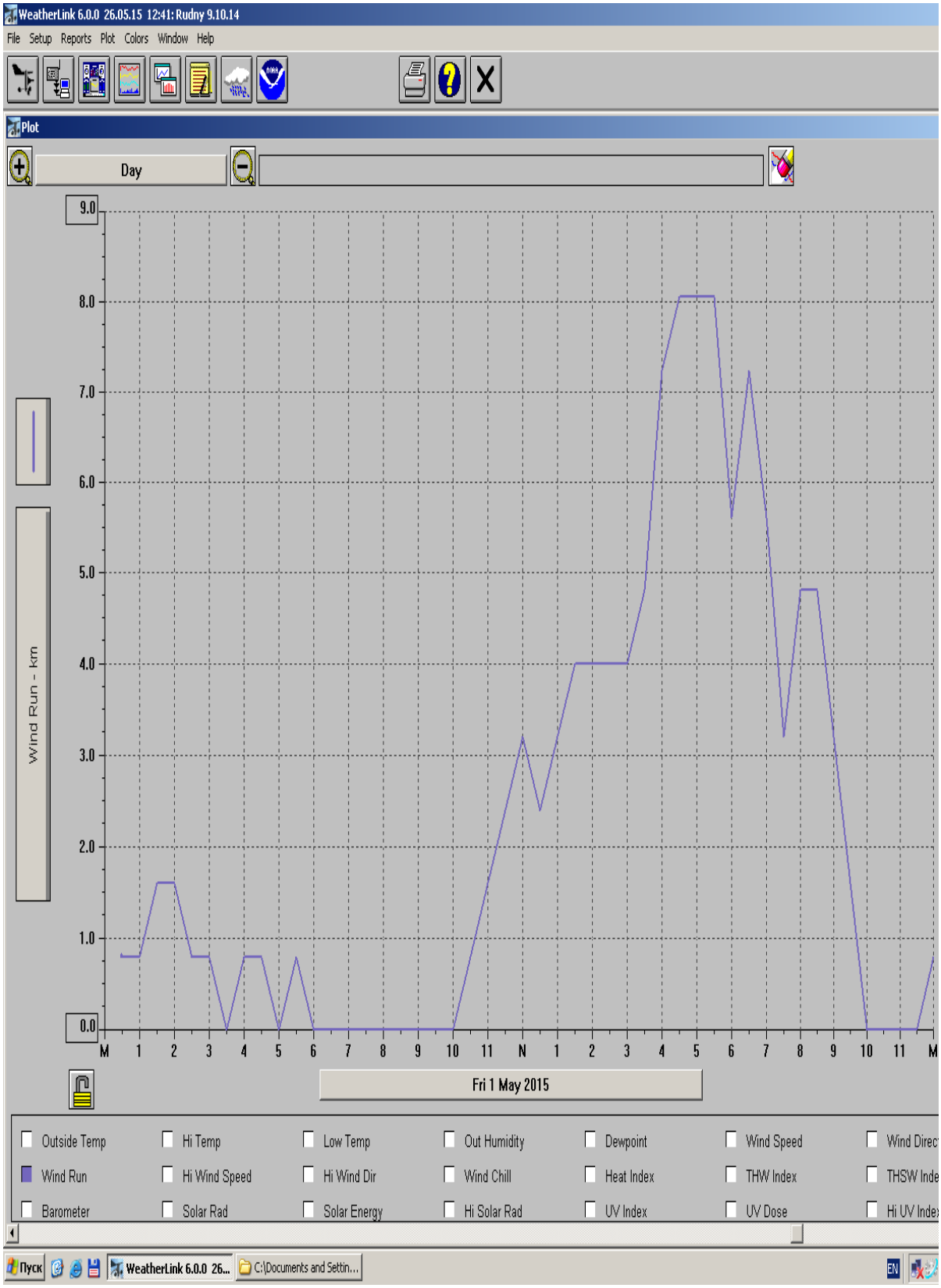


Figure 2.25 - The given graph of wind speed for 1 day

The given graph of wind speed for 3 days in Figure 2.26.

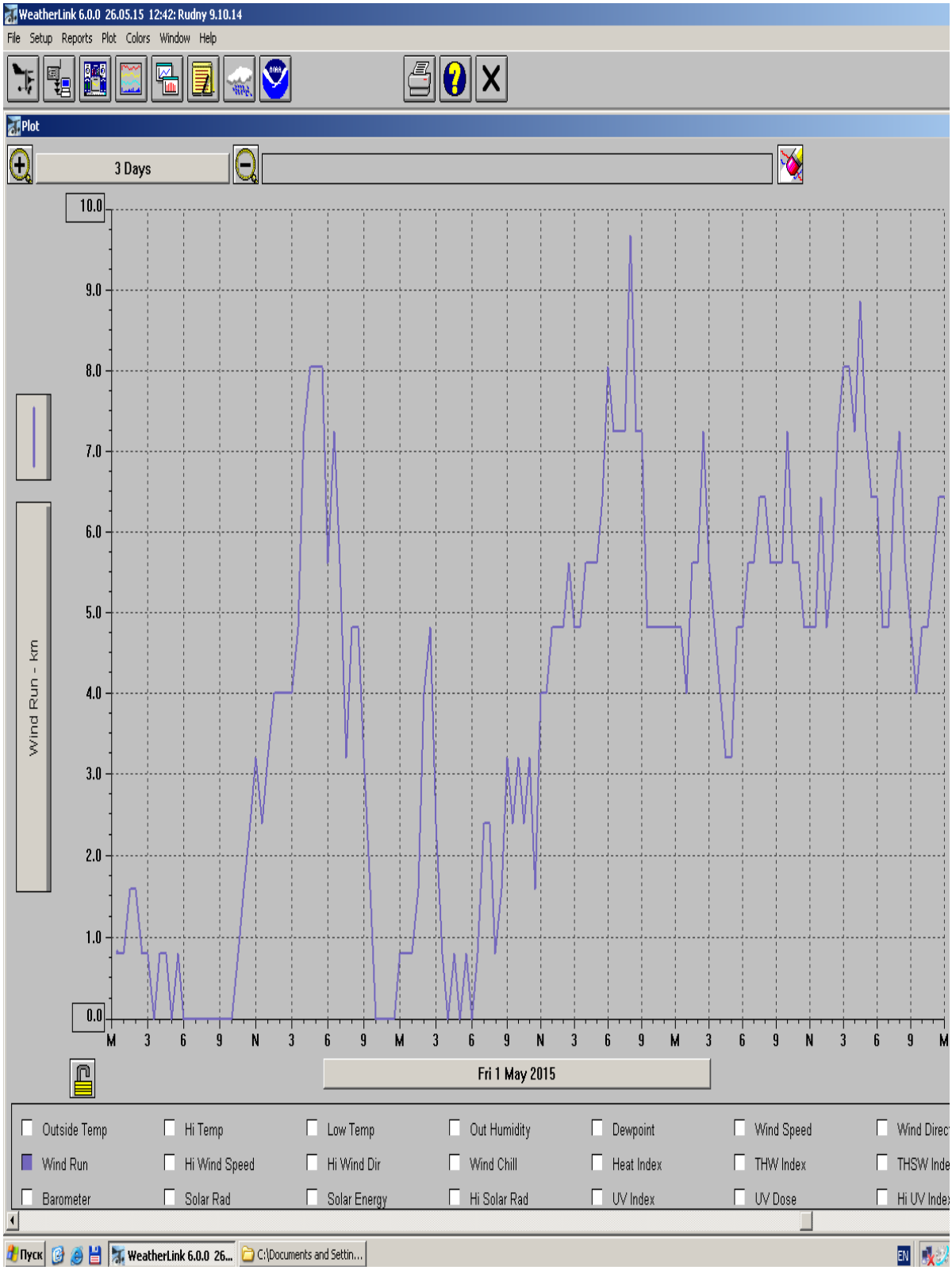


Figure 2.26 - The given graph of the wind speed for 1 day

The given graph of the wind speed for the week in Figure 2.27.

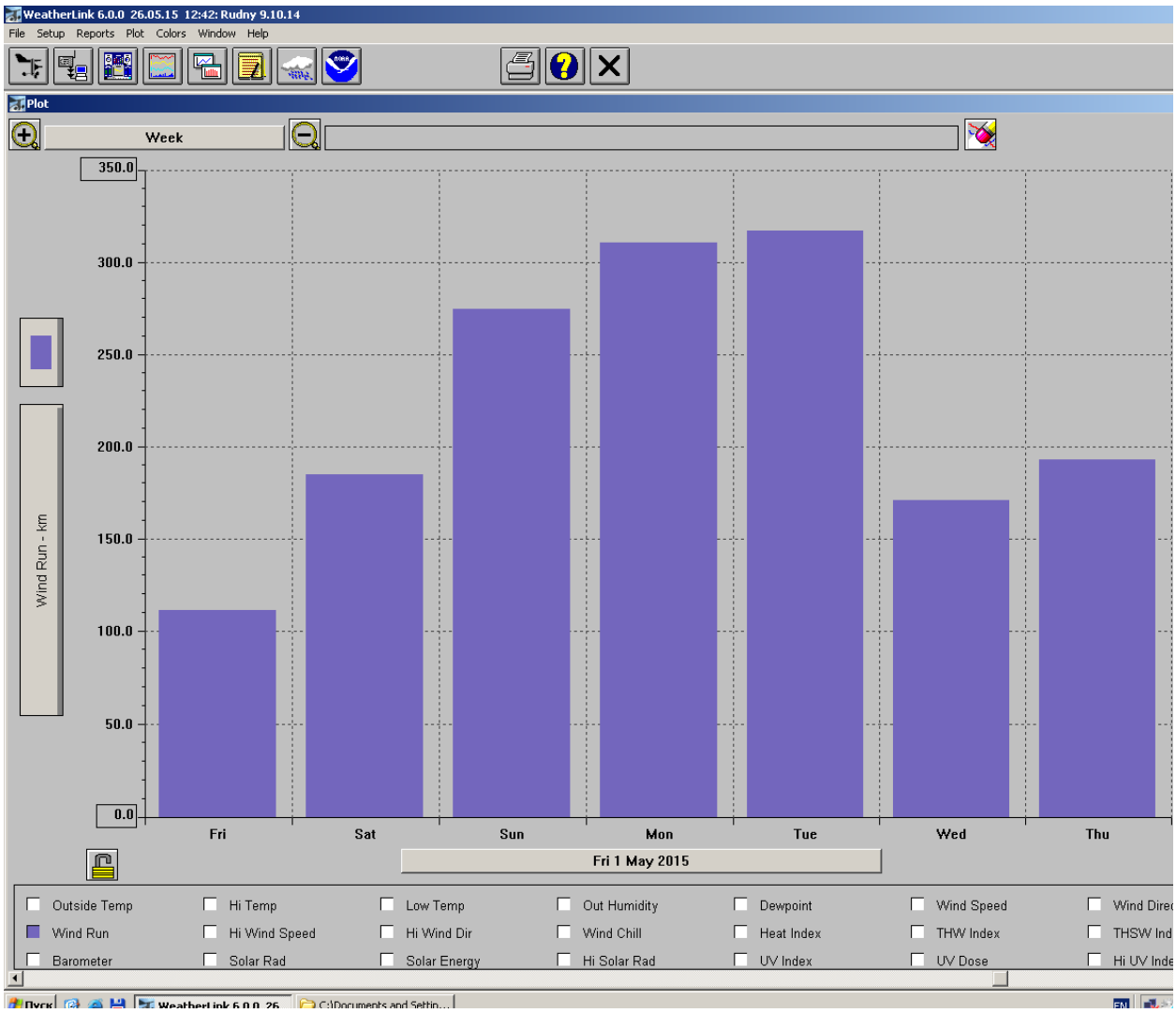
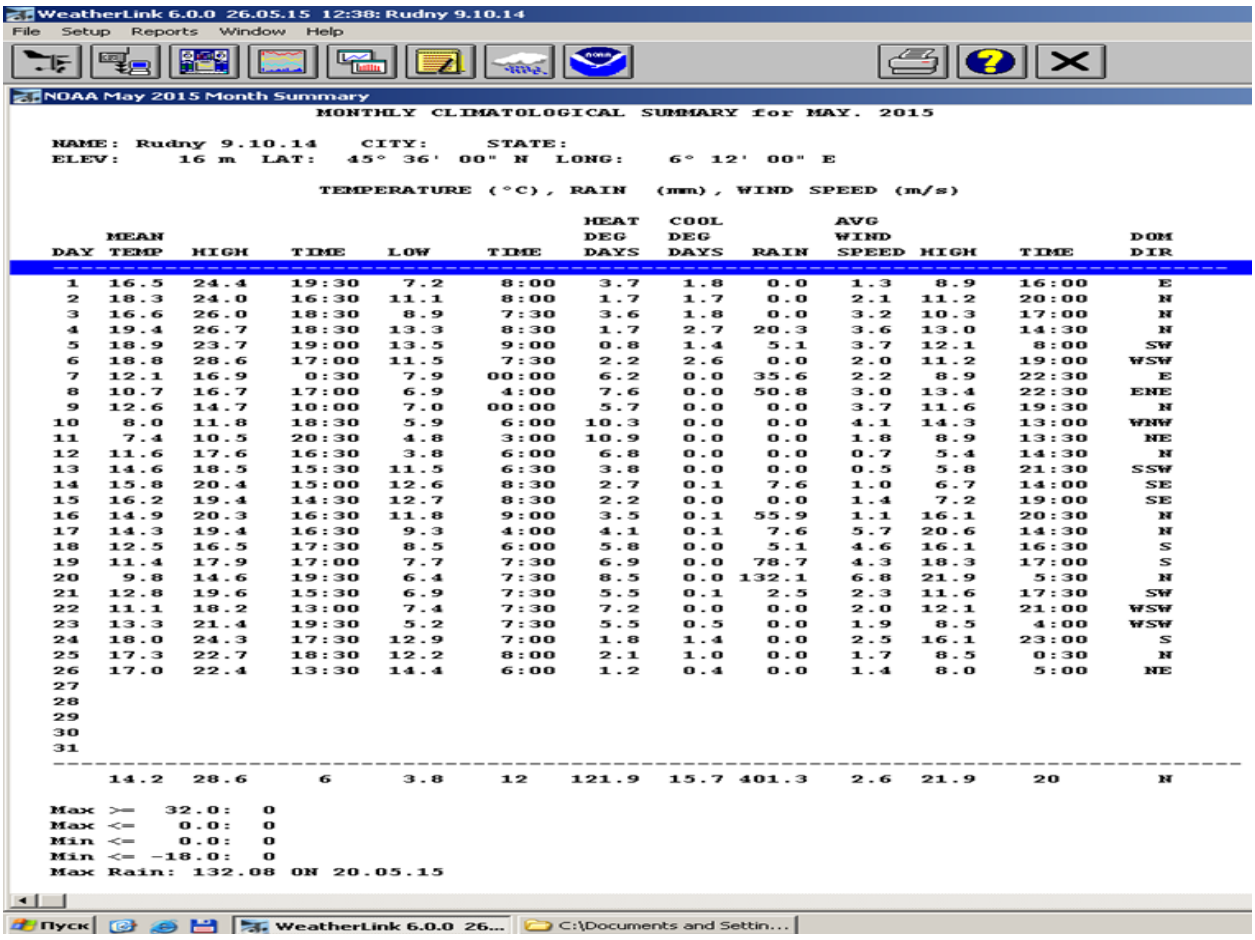


Figure 2.27 - The above graph of the wind speed for the week

2.10. The experimental studies were taken from the pressure readings from the Davis Vantage Pro 2 meteorological station.

The goal is to acquire practical and theoretical knowledge in the methods of taking readings from the Davis Vantage Pro 2 meteorological station and plotting the data; The given weather station readings for May are shown in Figure 2.28.



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NOAA May 2015 Month Summary

MONTHLY CLIMATOLOGICAL SUMMARY for MAY. 2015

NAME: Rudny 9.10.14 CITY: STATE:
ELEV: 16 m LAT: 45° 36' 00" N LONG: 6° 12' 00" E

TEMPERATURE (°C), RAIN (mm), WIND SPEED (m/s)

DAY	MEAN TEMP	HIGH	TIME	LOW	TIME	HEAT DEG DAYS	COOL DEG DAYS	RAIN	AVG WIND SPEED	HIGH	TIME	DOM DIR
1	16.5	24.4	19:30	7.2	8:00	3.7	1.8	0.0	1.3	8.9	16:00	E
2	18.3	24.0	16:30	11.1	8:00	1.7	1.7	0.0	2.1	11.2	20:00	N
3	16.6	26.0	18:30	8.9	7:30	3.6	1.8	0.0	3.2	10.3	17:00	N
4	19.4	26.7	18:30	13.3	8:30	1.7	2.7	20.3	3.6	13.0	14:30	N
5	18.9	23.7	19:00	13.5	9:00	0.8	1.4	5.1	3.7	12.1	8:00	SW
6	18.8	28.6	17:00	11.5	7:30	2.2	2.6	0.0	2.0	11.2	19:00	WSW
7	12.1	16.9	0:30	7.9	00:00	6.2	0.0	35.6	2.2	8.9	22:30	E
8	10.7	16.7	17:00	6.9	4:00	7.6	0.0	50.8	3.0	13.4	22:30	ENE
9	12.6	14.7	10:00	7.0	00:00	5.7	0.0	0.0	3.7	11.6	19:30	N
10	8.0	11.8	18:30	5.9	6:00	10.3	0.0	0.0	4.1	14.3	13:00	WNW
11	7.4	10.5	20:30	4.8	3:00	10.9	0.0	0.0	1.8	8.9	13:30	NE
12	11.6	17.6	16:30	3.8	6:00	6.8	0.0	0.0	0.7	5.4	14:30	N
13	14.6	18.5	15:30	11.5	6:30	3.8	0.0	0.0	0.5	5.8	21:30	SSW
14	15.8	20.4	15:00	12.6	8:30	2.7	0.1	7.6	1.0	6.7	14:00	SE
15	16.2	19.4	14:30	12.7	8:30	2.2	0.0	0.0	1.4	7.2	19:00	SE
16	14.9	20.3	16:30	11.8	9:00	3.5	0.1	55.9	1.1	16.1	20:30	N
17	14.3	19.4	16:30	9.3	4:00	4.1	0.1	7.6	5.7	20.6	14:30	N
18	12.5	16.5	17:30	8.5	6:00	5.8	0.0	5.1	4.6	16.1	16:30	S
19	11.4	17.9	17:00	7.7	7:30	6.9	0.0	78.7	4.3	18.3	17:00	S
20	9.8	14.6	19:30	6.4	7:30	8.5	0.0	132.1	6.8	21.9	5:30	N
21	12.8	19.6	15:30	6.9	7:30	5.5	0.1	2.5	2.3	11.6	17:30	SW
22	11.1	18.2	13:00	7.4	7:30	7.2	0.0	0.0	2.0	12.1	21:00	WSW
23	13.3	21.4	19:30	5.2	7:30	5.5	0.5	0.0	1.9	8.5	4:00	WSW
24	18.0	24.3	17:30	12.9	7:00	1.8	1.4	0.0	2.5	16.1	23:00	S
25	17.3	22.7	18:30	12.2	8:00	2.1	1.0	0.0	1.7	8.5	0:30	N
26	17.0	22.4	13:30	14.4	6:00	1.2	0.4	0.0	1.4	8.0	5:00	NE
27												
28												
29												
30												
31												
	14.2	28.6	6	3.8	12	121.9	15.7	401.3	2.6	21.9	20	N

Max >= 32.0: 0
Max <= 0.0: 0
Min <= 0.0: 0
Min <= -18.0: 0
Max Rain: 132.08 ON 20.05.15

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Figure 2.28- The given weather station readings for May

The given pressure chart for 1 day is shown in Figure 2.29.

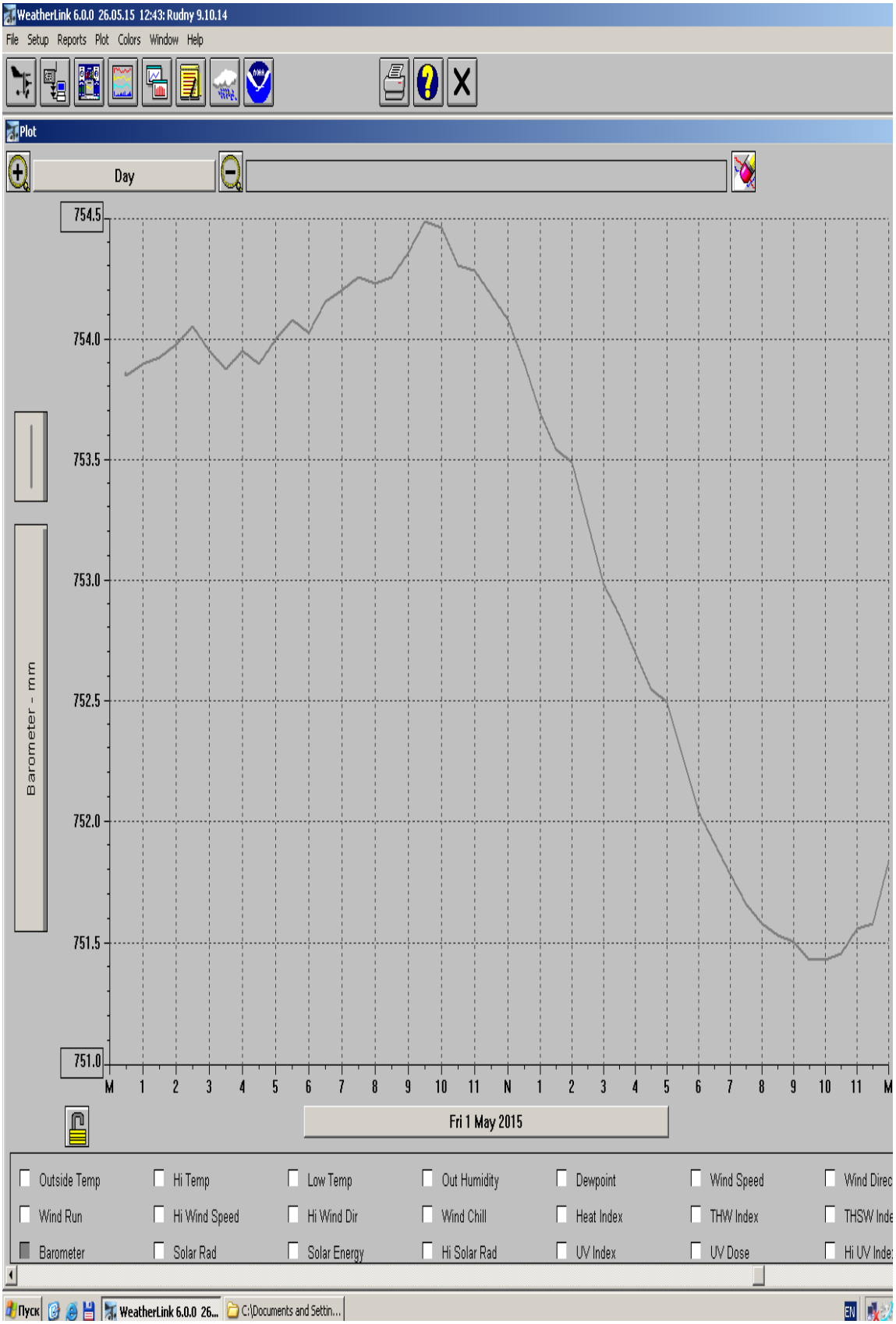


Figure 2.29 - Pressure chart for 1 day

The pressure chart for 3 days shown in Figure 2.30.

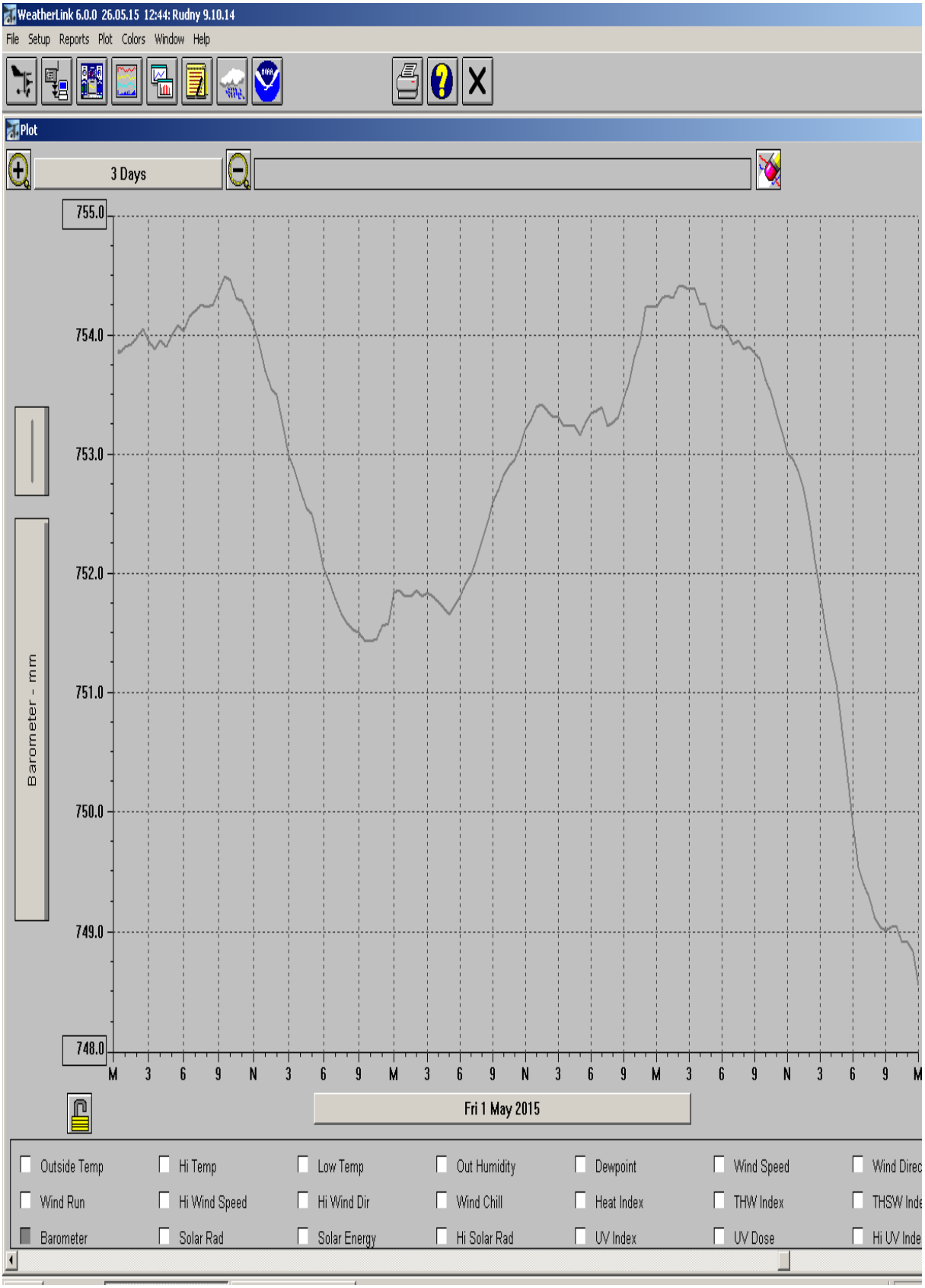


Figure 2.30 - Pressure chart for 3 days

The pressure chart for the week in Figure 2.31.

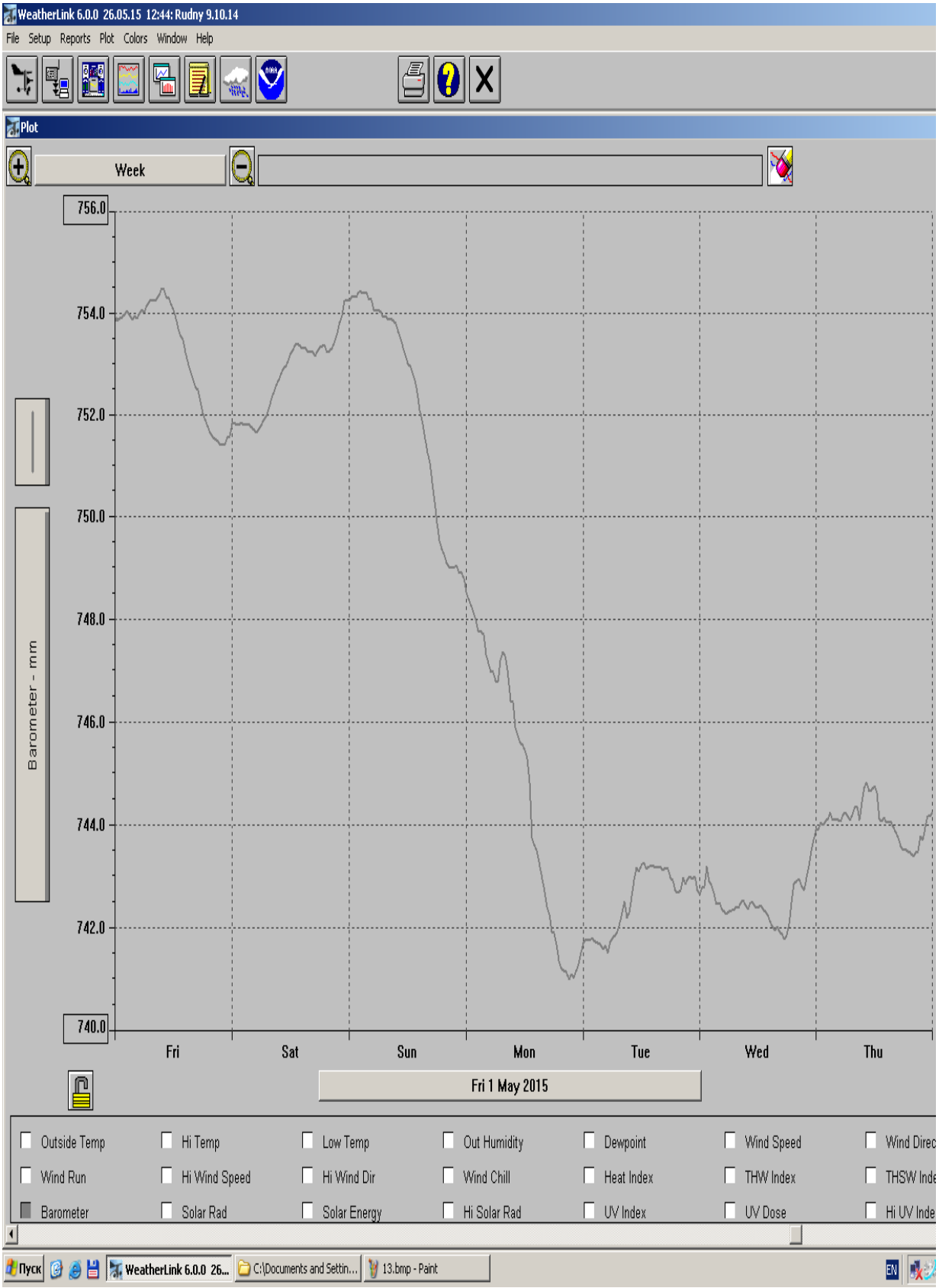


Figure 2.31 - Pressure chart for the week

2.11 Conclusions on the chapter

On the basis of the studies carried out, the following entries should be made in the presented chapter:

- the procedure for introducing the "Solar thermal device" into the educational process is shown;
- The theoretical part of the introduction of solar thermal device educational process;
- the scheme of inclusion of solar panels and possibility of carrying out of experimental researches at a consecutive and parallel connection is resulted;
- the possibility of selecting the battery charging regulators for a solar thermal device is shown;
- the possibility of selecting an inverter and a system controller for solar panels is shown;
- theoretical information on the role and purpose of the Davis Vantage Pro 2 meteorological station is given;
- the interface of the Weather Link type is shown, when the weather station is connected to a computer;
- Experimental temperature studies obtained using a Davis Vantage Pro 2 meteorological station for different periods of time are presented;
- graphs of temperature regimes obtained for a different period of research in the territory of the Rudny Industrial Institute;
- Experimental studies on the pressure for a different period of time are presented.

3 Introduction in the educational process of renewable energy equipment such as "Wind Turbine"

3.1 Familiarization with the device and the principle of operation of the equipment "Wind Turbine".

The aim is to get acquainted with the device and the operation principle of the equipment "Wind Turbine".

Wind turbine (wind power plant or short for wind turbine) is a device for converting kinetic energy of wind flow into mechanical energy of rotor rotation with its subsequent transformation into electric energy. Wind turbines can be divided into three categories: industrial, commercial and household (for private use).

Industrial are established by the state or large energy corporations. Unite in the network, the result is a wind power plant. The difference from traditional (thermal, nuclear) is the complete absence of both raw materials and waste. The only important requirement for wind farms is a high average annual wind level. The capacity of modern wind generators is 7.5 MW.

A large number of wind generators have been developed [14]. Depending on the orientation of the axis of rotation with respect to the flow direction, wind generators can be classified as follows (Fig. 3.1-3.3):

- with a horizontal axis of rotation parallel to the direction of the wind flow;
- with a horizontal axis of rotation perpendicular to the direction of the wind (similar to a water wheel);
- with a vertical axis of rotation perpendicular to the direction of the wind flow.

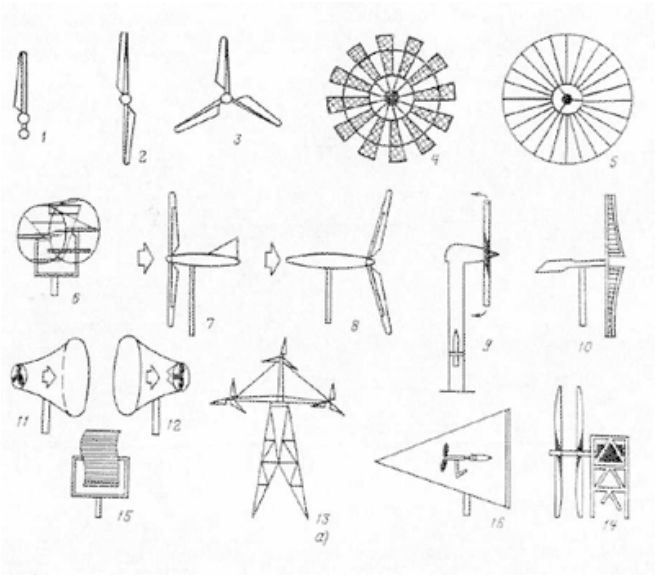


Figure 3.1 - Wind turbines with a horizontal axis of rotation

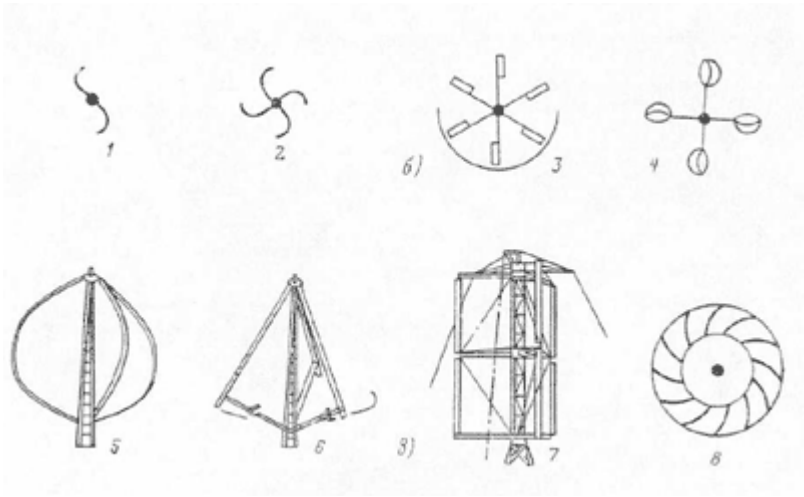


Figure 3.2 - Wind turbines with a vertical axis of rotation

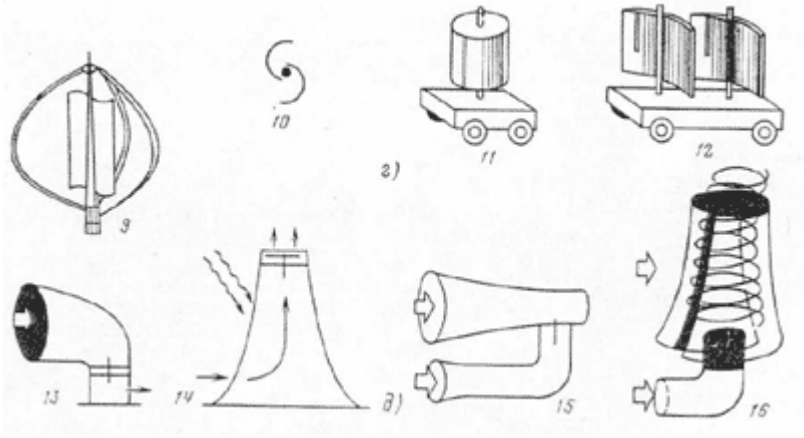


Figure 3.3 - Existing wind generators of other types

Designed and applied devices for converting wind energy into electricity without the use of moving parts. These include a device in which a process of cooling in a wind flow is used to generate electrical energy based on the thermoelectric effect of Thomson [8].

Wind turbines with a horizontal axis of rotation. Wind turbines with a horizontal axis of rotation can use lifting force or resistance force to convert wind energy. Devices using lifting force are preferable because they can develop several times greater force than devices with direct action of the resistance force. The latter, in addition, can not move at a speed exceeding the speed of the wind. Due to this, the blades on which the lifting force acts (the wind wheel) can be more rapid (speed - the ratio of the circumferential velocity of the surface element to the wind speed) and have a better ratio of power and mass at a lower cost per unit of installed capacity.

Renewable energy source of the type "Wind Turbine" (Figure 3.4) consists of:

1. Foundations
2. Power cabinet including power contactors and control circuits

3. Towers
4. Stairs
5. Turning gear
6. Gondolas
7. Electric generator
8. Tracking systems direction and speed of the wind (anemometer)
9. Brake system
10. Transmission
11. Blades
12. Systems for changing the angle of attack of the blade
13. Wind deflector

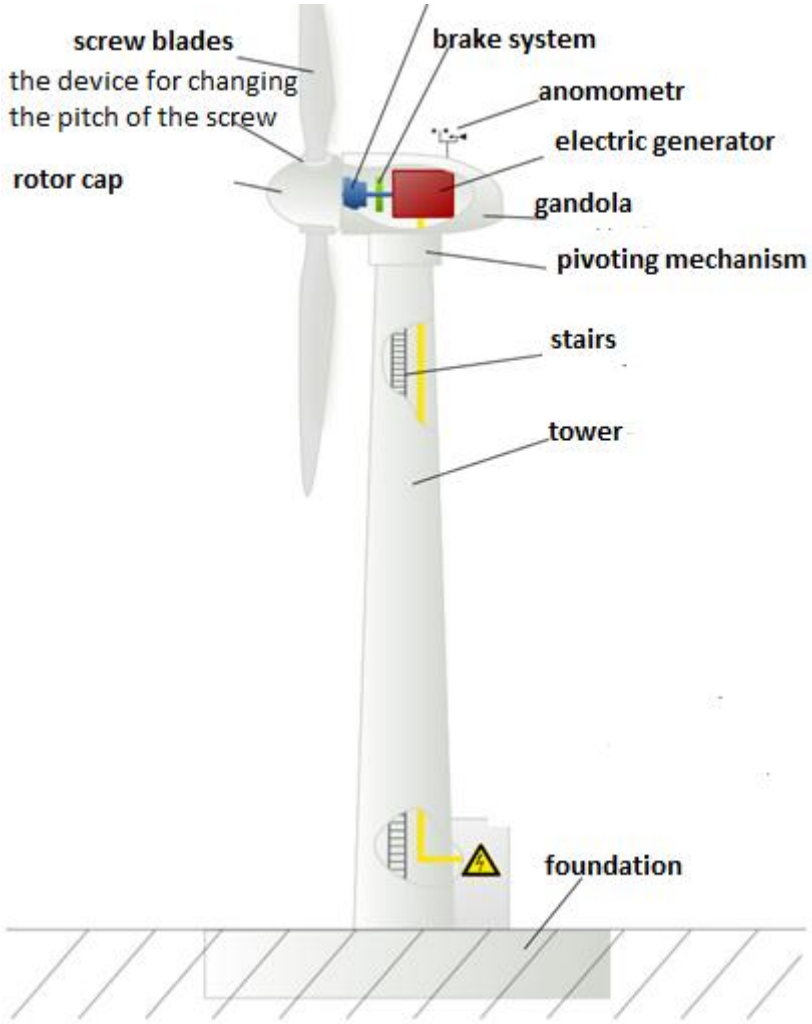


Figure 3.4 - Wind turbine with a horizontal axis of rotation.

Wind turbines with a vertical axis of rotation. Rotors have important advantages over wind turbines with a horizontal axis arrangement. Assembling the accumulating batteries and the control unit of the wind turbine is shown in the figures (3.5-3.6).

Figure 3.5 - Assembling the batteries of the wind generator.

Figure 3.6. - Wind turbine control unit.

For them, there is no need for devices for orientation to the wind, the structure is simplified and gyroscopic loads are reduced, causing additional stresses in the blades, transmission system and other elements of installations with a horizontal axis of rotation.

The danger of electric shock among other hazards differs in that a person is unable to detect the presence of voltage remotely without special devices, such as

driving parts, incandescent objects, open hatches, unchallenged edges of the platform at altitude. It is discovered too late - when a person is already amazed. Special attention should be paid to protection against electric shock.

Protective measures should be completely safe, the requirements must be reasonable without "reinsurance." According to statistical data, the number of electric shock accidents tends to decrease.

3.2 Schemes of operation of the wind power plant

The goal is to study the schemes of inclusion of the wind farm.

Wind energy use not only helps solve many problems of energy supply for remote sites and country houses and will receive independence from local energy supply organizations. [12].

Several common schemes for reconciling the consumer with wind power systems are given, but I would like to draw your attention to the fact that for each individual case it is necessary to draw up an individual project that will solve the task set for the system.In the figures (3.7- 3.10) the following types of wind generators are presented:

- Wind generator with battery pack;
- Wind generator with battery pack and switching with the network;
- Wind generator with battery pack and backup diesel generator;
- Hybrid autonomous system - sun-wind.

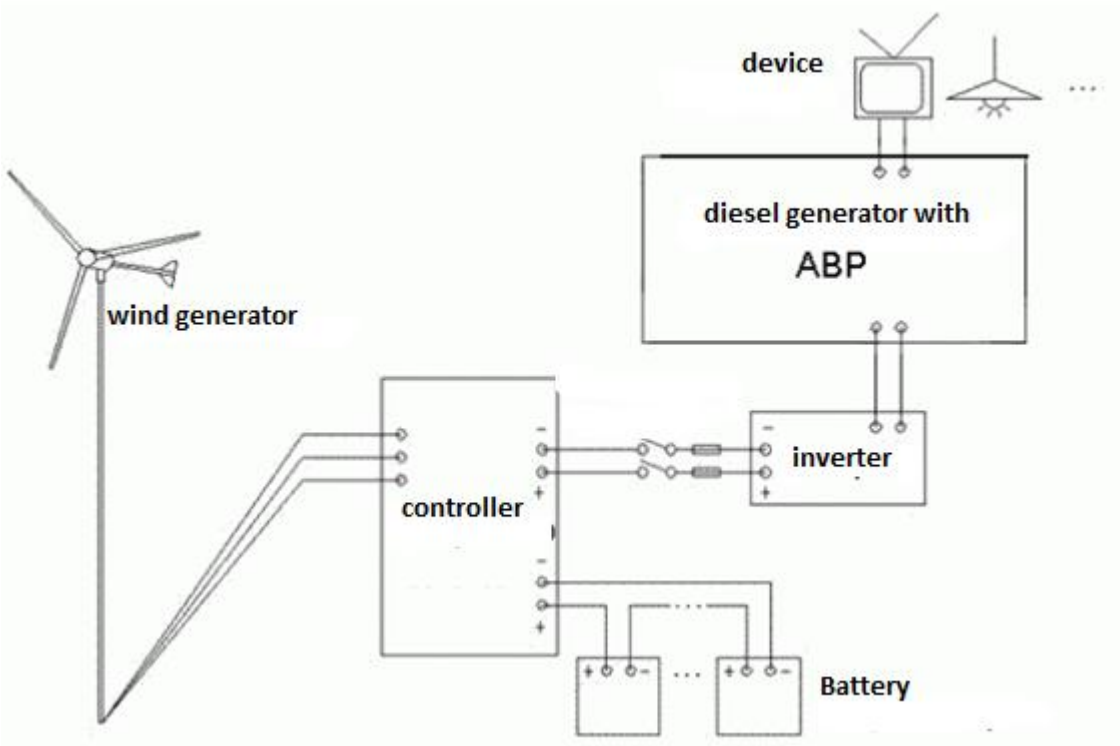


Figure 3.7 - Wind generator with battery pack. Consumer devices are powered exclusively from a wind power plant.

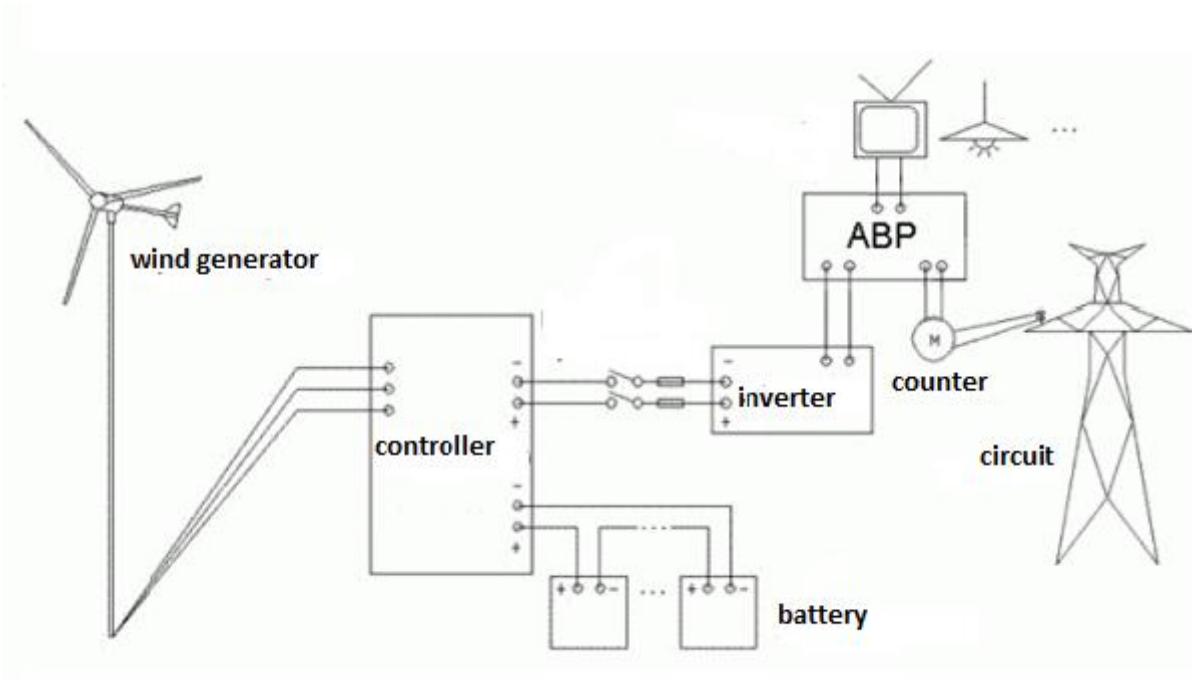


Figure 3.8- Wind generator with battery pack and switch with network.

If the wind has died down or its speed is insufficient for the output of the wind generator at operating speeds, and the backup batteries are at the same time discharged, the ATS allows you to switch the consumer to mains power. This scheme can also be used in the reversible mode, i.e. on the contrary. The wind generator is used as a backup power source. At the same time, the ATS will switch the wind turbines to batteries in the event of a loss of power from the mains.

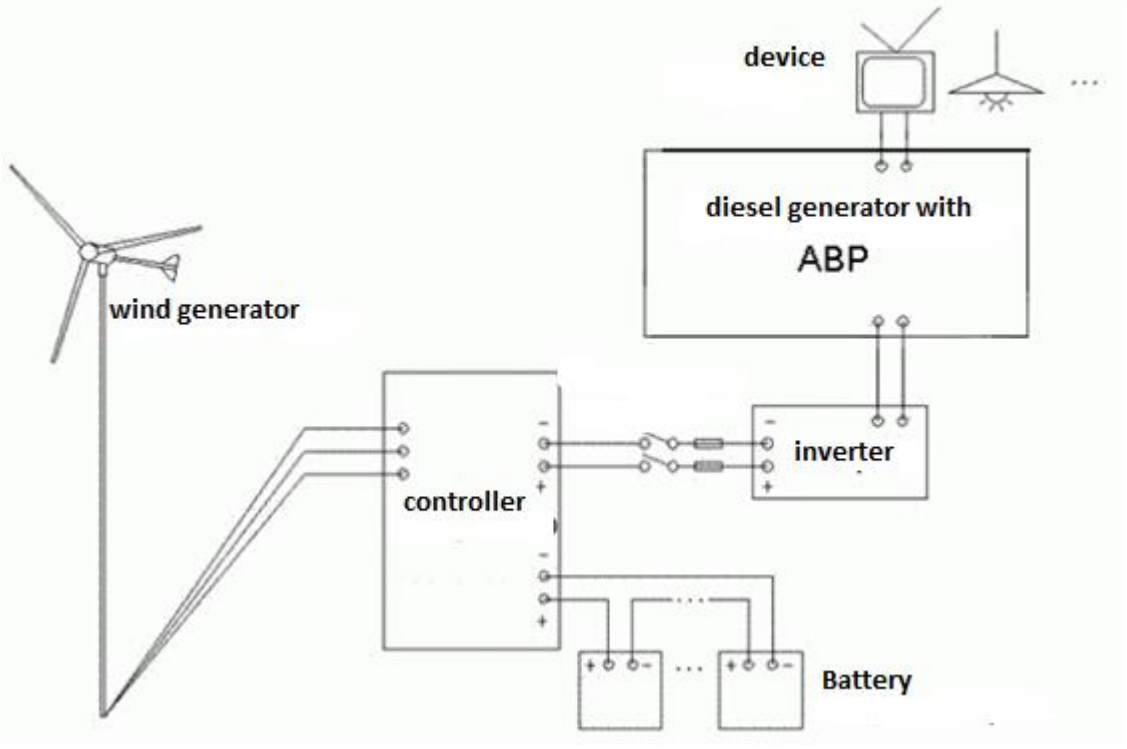


Figure 3.9 - Wind generator with a battery pack and a backup diesel generator.

If the wind has died down or its speed is insufficient for the output of the wind generator at operating speeds, and the backup batteries are at the same time discharged, the backup generator automatically starts.

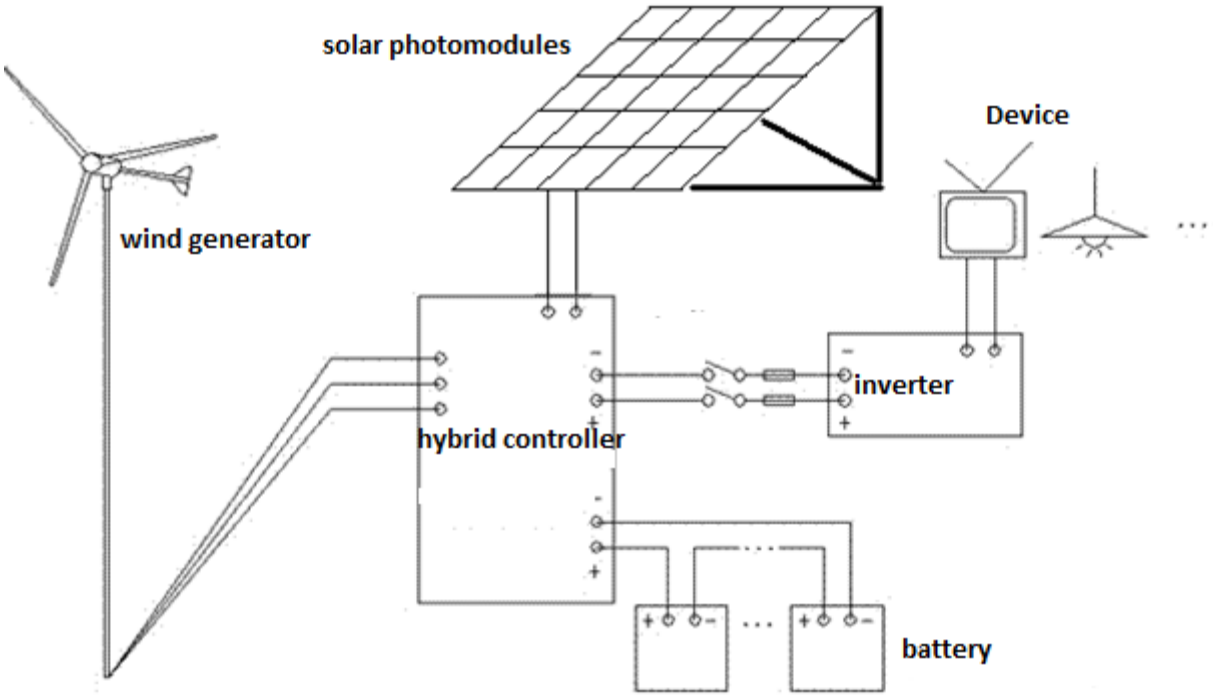


Figure 3.10 - Hybrid autonomous system - sun-wind.

This option involves connecting solar cells to the wind turbine system. The connection can occur via a hybrid controller or using a separate controller used for solar systems.

3.3. Study of the basic principles of the choice of the wind power plant.

The aim is to study the basic principles of choosing a wind farm.

Before choosing a wind turbine, you need to determine the power and function of the device. Carefully study the varieties of the wind farm and get acquainted with the climatic conditions of the region in which the wind turbine is planned to be installed [8]. Determine the output power of the wind farm, which directly depends on the power of the converter (inverter).

The second name of the output power is the peak load - the total number of devices that will simultaneously work with the wind generator. The output power is defined as the total power of the wind turbine. Even with a rare but large consumption of electricity, you should choose a high-capacity wind generator. To increase the output power, several inverters must be installed. Time for continuous operation of the device is determined by the capacity of the battery, which are installed in the wind farm. In windless weather, the batteries provide electricity.

The battery charge rate is determined by the device's power, wind speed, installation height and the terrain on which the wind turbine is installed. The higher the power of the wind generator, the faster the battery charge. With a constant consumption of electricity or with a weak wind, more powerful models of the wind farm are chosen. To increase the speed of battery charging, several generators should be connected to the wind farm. Do not buy a lot of batteries, with a weak wind force, as the wind generator will not have time to charge all the batteries. If the batteries are not fully charged, this leads to a rapid exit of their system, so the number of batteries should be calculated from the power consumption of all electrical appliances in the house. When choosing a wind farm, you should pay attention to the main factor - the generated energy of the device. This criterion is indicated in the technical characteristics of the wind turbine. To determine the power consumption of the house in which the wind farm will be placed, you should review the electricity bills for the last 12 months, and derive the minimum, average and maximum energy consumption.

With the help of studies of the meteorological station, it is necessary to know about the average annual wind speed at the proposed site of the installation of the wind farm. Optimum wind turbine operation is ensured with wind 5 m / s.

It is better to install the wind generator as an additional power source paired with a diesel or gasoline generator. When testing the wind turbine in operation, it is necessary to pay attention to the noise level and the need for maintenance of the wind farm. Some powerful wind generators have a sufficiently high noise level, which leads to discomfort and problems with neighbors.

The average service life of the wind generator is (6-7) years. It is better to give preference to the wind generator, whose blades are made of hard materials: fiberglass or metal.

It is necessary to pay attention to the optimal operation of the wind turbine at the average wind speed, which is typical for this region.

Direct-drive wind generators are much easier to install, easy to assemble and do not require additional maintenance, while gearboxes, despite the complexity of the installation, provide greater power and better windmill performance.

The cost of a wind generator directly depends on such factors:

- number of blades,
- battery power,
- generator power,
- number of inverters,
- blade making material,
- gearbox,
- rated wind power,
- wind generator type: horizontal, vertical,
- material from which is made installation,
- the availability of additional components.

3.4 Turning on and off the wind turbine.

The goal is to turn on and turn off the wind farm.

It is necessary to activate the wind turbine in its operating state, but it is necessary to know the precautions when working with the installation and to study the order and the start-up algorithm before operation. Safety rules must be observed to safely stop the wind turbine. As soon as the wind generator stops, it is necessary to check the braking state. On inspection, the following items should be noted:

The lifting equipment must be authenticated for suitability. Lifting equipment is installed on a hard ground so as not to interfere with the rotation of the rotor. Do not mount mounting equipment on the blades of the wind generator. In case of dull weather, do not stand under a wind farm. The installation engineer must be equipped with a safety rope, dressed in safety non-slip shoes and a helmet. When servicing, keep a certain distance to the wind farm for safety.

- Do not service the wind turbine in stormy weather.

- Do not stand under the wind turbine at the time of servicing to avoid injury from falling parts.

I will pay attention to warning symbols - these are tips of potentially dangerous places !!! Stay vigilant and follow the operating instructions!

When installing the wind generator, the installer and the user should familiarize themselves with the operating instructions. Installation, adjustment and maintenance of the wind farm must also be carried out in accordance with the operating instructions. The handbrake is a reliable brake system, easy to operate, can stop the wind turbine at any time (Figure 3.11).

Figure 3.11 - Hand brake of the wind turbine.

Check the main parts of the wind generator before starting should be carried out in the following sequence:

- Check blades, rotor, bow cone, generator housing and also all fasteners. Check the reliability of their connection;

- Check whether the angle of the blades is correctly set;

- Check the connection of the support to the foundation; - Check the foundation bolts, tightly tightened;

- Check whether the friction of the rotor on the generator housing;

It is necessary to check the output electrical connections from the wind turbine:

- Check whether the 3-phase wires are tightly connected to the terminal block of the wind generator;

- Check the cable passing in the nutria of the support, whether it is twisted or if there is any friction about the cable;

Check the wind generator controller and the handbrake:

- Check whether the steel cable of the hand brake is connected to the brake system inside the wind turbine, whether it is in a taut condition;

- Check the emergency power supply and batteries. Did the voltage in them reach a critical value whether they are connected to the controller;

- Check blade angle adjustment and set the required angle;

- Slowly loosen the handbrake and see if the blades rotate from the oncoming wind.

Check the electrical components of the system for suitability. Check the electrical equipment for suitability for this system: On / off Grid: Wind generator, battery, inverter and load shedding. Make sure that they are installed according to the "user manual" and are connected correctly and correctly.

The test run is carried out in the following sequence:

- Before starting, the manual brake system of the wind generator must be in the "start" state;

- Disconnect the electromagnetic brake and start the wind generator by clicking the controller on the control panel;

- At a wind speed of 3 m / s. The wind wheel should be ready, run the generator. For the first time, the generator can only start at increased wind speeds. This is normal. To the passport value in the process of operation will pass;

- The wind turbine should work smoothly and there should be no vibrations. Check the output phases of the three-phase generator. The voltage across all 3 phases must be the same. It is necessary to check how the power output varies with different wind speeds. With a standard wind speed, the output should not exceed 1/3 of the rated output;

- After starting the wind turbine, follow the instructions. Check the controller, batteries and inverter. Everything works well. Check the load;

- After the above mentioned test, make sure that everything works as indicated in the instruction.

The shield, panel and converter of windmill control are presented in Figures (3.12 - 3.14).

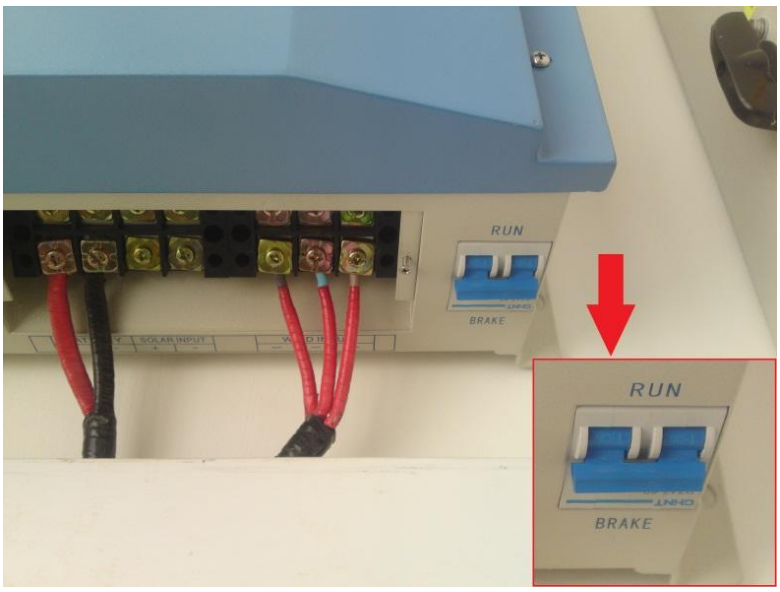


Figure 3.12 - Control panel, switch on and off the wind turbine.

Figure 3.13 - Control panel on the wind power panel.

The usual mode should include: - When the wind turbine works, everything works correctly; - The operator must be allowed to work with this equipment, who is familiar with the principles of operation and with the instruction of wind turbines; - It is necessary to work according to the instructions. It is strictly forbidden to break the rules.

Figure 3.14 - The converter "Inverter".

The usual stop of the wind farm is carried out in the following sequence:

- Automatic stop is made if the start switch is turned to the "off" position;
- Manual stop, in case of bad weather or a hurricane, it is necessary to switch to "manual control" and control the blades to turn them so that the wind wheel stopped and at the same time use a mechanical brake (Figure 3.11);
- There is no need to disassemble the whole system, but for a long shutdown it is necessary to disconnect the controller, batteries and inverter;
- To restart, press the "start" button to allow the wind turbine to rotate.

3.5 Maintenance and installation of wind turbines.

The goal is to study the basic requirements for servicing and installing the wind farm.

When servicing the wind farm, regular inspection and maintenance should be carried out.

- check if there are any strange noises or vibrations during normal operation. If detected, stop the wind farm and repair the malfunction;
- check whether the angle of the blades varies with the wind speed; - check the output voltage in the three-phase wind power network. Whether everything is working correctly. Is the power produced commensurately?
- check if there is enough charge in the batteries.

Maintenance during operation up to 1000 hours:

- check all fasteners, do not loose it, if it needs to be tightened again. Especially check the foundation bolts, the connecting flange, the attachment of the

blades and all other attachment points.

- check all welding elements on the parts. Are there any cracks or defects? - check the handbrake. Tightened cables. If there are any faults, remove them.

- check the output circuit of the generator.

- check the connection of the three-phase output of the generator to the electrical shoe. Is it dense?

- check the condition of the electrical contacts.

- check whether there is excessive friction in the current-carrying bearing of the generator.

- check whether the voltage is balanced by all 3 phases at the output of the generator. - check if there is enough charge in the batteries.

- Lubricate the key parts as follows: - open the cover on the cowl and lubricate everything beneath it.

- Open the bow cone and lubricate the bearings.

Maintenance after 3000 hours of operation.

- Repeat the maintenance in the "Maintenance for operation up to 1000 hours."

- Check the technical condition of the rotor.

- Check the position of the blades. Are there any cracks or defects on the surface.

- Check those blades for turning, does not this lead to an imbalance of the rotor.

- Clean the bearings. When identifying defects in parts connected to bearings, they must be replaced.

To service the wind farm is necessary for the whole period of work:

- it is necessary to lubricate the bearings every year.

- check the rotary elements permanently, replace them with defects.

- Check fasteners regularly. Does it preserve its integrity.

- Regularly check the steel cable does not rub it. If necessary, replace.

- regularly check the charge in the batteries.

The wind farm is designed on the principle of trouble-free operation and free maintenance [9, 10]. If the wind generator is installed and used for its intended purpose. Usually this does not lead to malfunctions. If there are any emergencies, you need to refer to Table 3.1:

Table 3.1 - Fault table in the wind farm and solutions

Malfunction	Analysis of the cause	Decision
1	2	3
The appearance of vibrations	1. The tension of the steel cable is weak 2.The blades are damaged 3. The blade fastening is weakened 4. Disbalance of blades in connection with glaciation.	1. Tighten the steel cable 2. Replace and balance again 3. Tighten the fasteners 4.Delete the glaciation
Blades do not rotate at the right angle to the wind	1.Too much dirt on the surface of rotation. 2. Bearings are shown inside the axis of rotation. 3. The vertical axis is distorted.	1. Clean and lubricate 2.Replace the bearing 3. Adjust the vertical axis
Strange noise	1. Fastening is loosened 2. Friction in the system 3.The bearings are damaged	1.Check the tightness of all fasteners. 2.Check the entire system and correct the malfunction. 3.Replace the bearing
The rotor blades lost control at the rotational speed.	1.Mail in control system 2.KZ in the winding of the generator or output network 3. Problems in the mechanics of the knot of rotation	1.Zamerit charge in the batteries, if they are discharged charge or replace. 2. Find the place of faults. Eliminate malfunction and insulate 3.Check the lubrication and the entire rotation system
The rotor speed is obviously low	1. Wrong angle of rotation of the blade 2.KZ in the stator of the generator 3.KZ in the output from the generator 4. Friction about the brake 5. The switch is in the "Off" position	1. Change the angle 2. Find the place of faults. Repair the fault and insulate it. 3. Find the place of fault. Repair the fault and insulate it. 4.Correct the brake system 5. Switch to "On"

Table continuation 3.1

1	2	3
The generator has an output low voltage	1. Low speed of rotation 2. Problems with permanent rotor magnets 3. Short circuit on three phases of the stator 4. Bad connection of wires. 5.Kz in the rectifier 6. Small cross section of cables.	1. Find the cause of the fault and remove it. 2. Replace the rotor 3. Find a place for faults and repair 4.Restore connections 5. Replace 6. Increase the cross-section of the cables
At the outlet to the network there is no alternating current	1. Fuses of the generator went out and building. 2. The output circuit is not closed 3. Stator winding holes	1. Find the cause of the fault and remove it. 2. Find a breakdown and fix it. 3. Disassemble and repair
AC output OK, DC output not OK	1. Fuses in the DC circuit are not OK 2. The output circuit is not closed 3. Rectifier burned ou	1. Replace 2. Check the entire circuit. 3. Replace
Low battery capacity	1. Low output voltage insufficient for charge 2. Bad contact with batteries 3. The batteries are faulty.	1. Check the items mentioned above 2. Strip the joints 3. Replace the batteries

3.6. Familiarization with the device and the principle of operation of equipment such as "Solar thermal device".

The aim is to get acquainted with the device and the principle of operation of the equipment "Solar thermal device".

Vacuum solar collector. Solar energy is one of the safest and renewable energy sources on our planet. Its use for obtaining hot water and heat increases every year. Perhaps by 2020, solar energy will provide one-fifth of the world's electricity consumption. To convert solar energy into thermal energy, a solar system is used - a flat or vacuum solar collector.

Solar energy is inexhaustible [6,7]. While there is a sun, solar water heaters convert solar energy into heat.

The service life of the main components of the system is up to fifteen years or more. In case of using other energy sources, a combined system can be implemented. Significant economic benefits, long-term benefits from a one-time investment.

Solar energy is one of the cleanest, renewable sources of energy, there is no pollution of the environment.

The operation of a domestic solar water heater can reduce CO_2 emissions in proportion to the amount of fuel saved. In this case, the greenhouse effect of carbon dioxide emissions is reduced.

Design features. The solar water heater converts solar energy into thermal energy, which is used to heat water. Solar water heater consists of glass vacuum collectors, heat accumulator, main frame and connected with the system of highways is presented in Figures (3.15-3.16).

3.15 - Vacuum solar collector.

The conversion of solar energy into thermal energy is carried out through glass vacuum tubes. The heated water rises, and the cold water down. This is how the water temperature difference in the vacuum tube is formed. Thus, the water is heated and the system circulates.

Flat solar water heater-collector - a device with a flat-panel absorbing panel and a flat transparent insulation to absorb solar energy. This is a flat heat-absorbing panel - an absorber, with an area of 1-2 m, in which there are channels for liquid. The surface of this panel, black, for better heating from the sun.

Active systems use electric pumps, valves and controllers to circulate the coolant through the manifold. More expensive than passive systems, but also more effective. Active systems are often easily modified than passive systems, because their tanks should not be installed above or close to the collectors.

Passive systems transfer finished water or heat transfer medium through a system without pumps. Passive systems have the advantage that disabling

electricity or damaging the circulation pump will not be a problem. This makes passive systems generally more reliable, easier to maintain, and perhaps more durable than active systems. Passive systems are often less expensive than active systems, but are also generally less efficient due to slow circulation in the system.

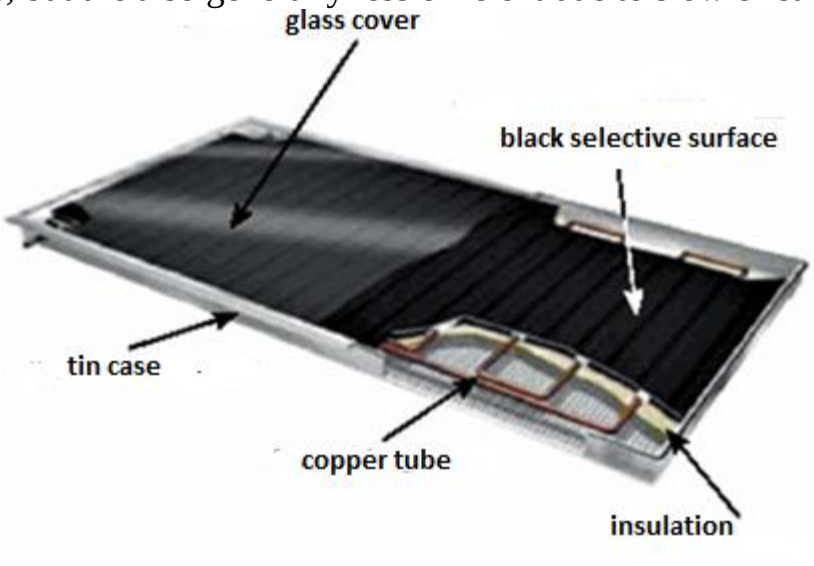


Figure 3.16 - Design of a flat solar water heating collector.

Active open loop systems use pumps to circulate water through manifolds. This system is effective and lowers operating costs, but it is not suitable if your water has a large amount of salts or is acidic, because deposits and corrosion will gradually disable the system. Active open loop systems are popular in regions with positive temperatures or seasonal use, although vacuum tube systems are able to withstand negative temperatures without fear of damage to temperatures of -40 ° C.

Active systems with closed loop. In these systems, the coolant of the collector is usually water-glycolium antifreeze. Heat exchangers transfer heat from the coolant of the primary circuit to water, which is stored in tanks (heat accumulators). Heat exchangers with a double wall or two heat exchangers located in the heat accumulator prevent contamination of the finished water. Some standards require double walls, when the coolant is not water or there are increased requirements of the sanitary and epidemiological services. Systems with a closed loop are popular in areas subject to long-term negative temperatures, they have good protection against freezing. Systems with antifreeze are more expensive to buy and install, and antifreeze should be checked every year and replaced every few years, depending on the quality of the antifreeze and system temperatures. Some types of solar water heaters with vacuum tubes. Thermosyphon systems (water heaters of open type or low pressure) thermosyphon systems work on the principle of aspiration of warm water upward, a phenomenon known as natural convection, used for circulation of water through a reservoir and a tank. In this type of installation, the tank must be located above the manifold.

Heat accumulators provide an opportunity to store heat energy and give out to the consumer as needed. This in part allows to solve the problem of temporary absence of the sun and to ensure a constant operating temperature. Heat

accumulators can be installed directly on solar collectors (thermosyphons) or separately indoors. Heat accumulators installed on solar collectors.

Heat accumulators have two tanks - internal and external. The inner is made of stainless steel. Between the inner and outer tank is installed polyurethane foam insulator thickness 50mm (Figures 3.17-3.18).

Figure 3.17 - Internal heat accumulator.

Figure 3.18 - External heat accumulator.

There are a large number of schemes for connecting the current heating system to the solar system, so the configuration of the heat accumulator varies.

Thermosyphon with built-in heat exchanger provides the possibility of operation at main pressure. The heating medium is heated through a heat exchanger from a spiral copper pipe located inside the heat accumulator.

The principle of operation of the SVNU type is the same as that of a conventional low-pressure thermosyphon. But instead of using water directly in the heat accumulator, this SVNU uses a copper spiral heat exchanger in the tank. The advantage of this system is that it can be used in systems with low water quality, as corrosion and scale formation inside vacuum tubes and heat storage are almost completely eliminated. For areas with very low temperatures, it is possible

to fill the heat accumulator with antifreeze.

The most efficient and common solar water heaters. Easily integrated into existing heating systems or hot water supply. Suitable for all types of climate and are recommended for areas with low temperatures (up to -50 ° C) and low values of solar radiation. Equipped with a controller, the collector automatically maintains the most optimal circulation parameters, has anti-freezing mode, provides the set temperature. With insufficient solar activity, the controller may include an additional electric heater installed in the heat accumulator. The closed-loop system is shown in Figure 3.19.

The structural component of the thermosyphon with an integrated heat exchanger and a vacuum solar water heater - a collector with a remote tank is shown in Figures (3.20-3.21).

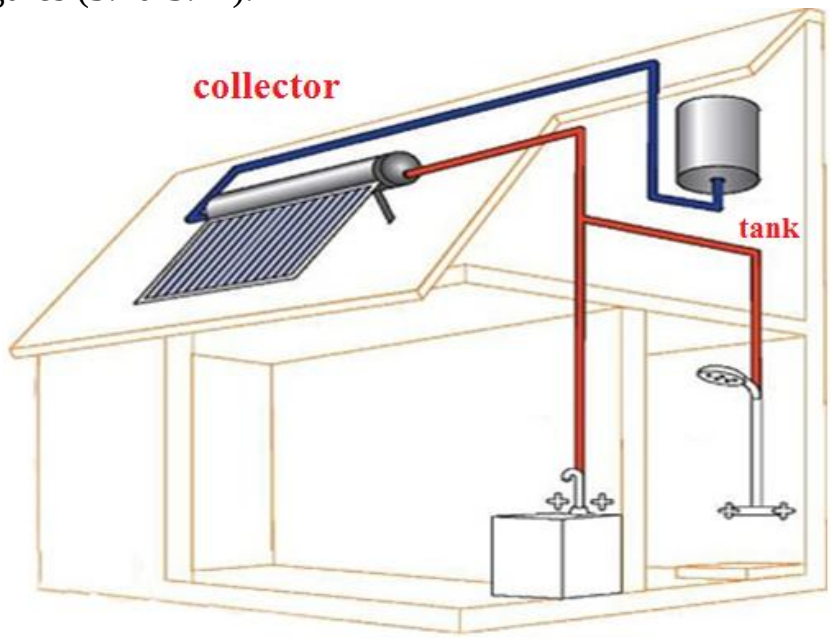
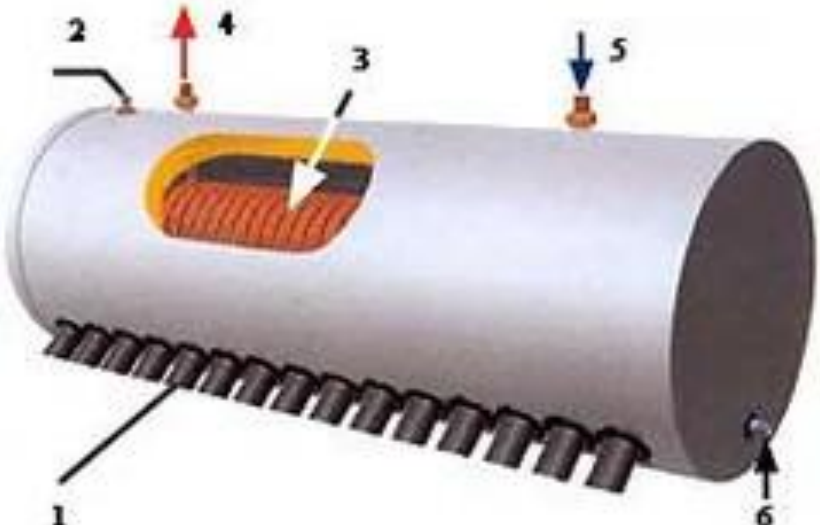
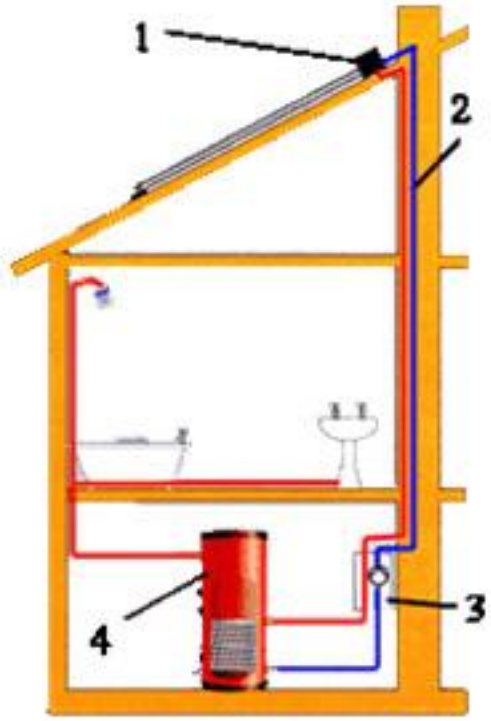


Figure 3.19 - Closed loop system.



1. Vacuum tubes, 2. Discharge valve, 3. Heat exchanger, 4. Output, 5. Input, 6. Tap for filling the tank.

Figure 3.20 - Constructive component of thermosyphon with built-in heat exchanger



1. Collector, 2. Pipes, 3. Solar station (pump, valves, manometer) and controller, 4. Heat accumulator connection diagram.

Figure 3.21 - Vacuum solar water heater-collector with an external tank

3.7 Technical description and installation of the solar collector controller.

The aim is to familiarize with the device and equipment of the solar collector controller.

The solar collector controller performs intelligent control and ensures the automatic operation of the system (Figure 3.22).

Figure 3.22- Solar collector control.

Description of the functional - an extract from the documentation for the controller:

- Clock, timer.

- Water temperature display .
- Water level indicator .
- Automatic system operation control mode .
- Forced water dialing, command from the controller's console .
- Water set by time (timer) .
- Auto water pumping up to programmed level .
- Increasing the hydraulic pressure in the system when water is withdrawn .
- Forced electric heater activation.
- Switching on the heating according to the schedule (timer).
- Switching on the hot water circulation.
- Switching off - blocking the hot water line.
- Protection against insufficient water inlet pressure.
- Protecting the solar collector tubes from overheating.
- Information protection in the case of power failures.

As can be seen from the description of the controller functions, optimally configure the system for operation in different conditions, as well as flexibly manage the system during operation.

In order to save electricity, knowing that there will not be a large flow of hot water, you can tell the controller not to turn on the heating of the water heater at night. Knowing that there is a constant high consumption of hot water, instruct the controller to maintain the maximum possible volume of water in the tank, and turn on the electric heating for the fastest possible receipt of hot water without waiting for the collector to warm up the water.

Features of a solar collector of a split system:

- Year-round operation;
- Effective with diffusion radiation (no direct sunlight);
- High efficiency in the autumn - winter period (developed for "not warm" countries);
- High efficiency,
- Absorption coefficient of solar energy up to 98%;
- Application of the coolant circulation for water heating.

Installation and commissioning of the solar collector:

- When laying cables, it is necessary to provide measures ensuring protection against mechanical damage and damage by fire.
- The controller should not be located in a room where mixtures of flammable gases are present or may occur.
- External conditions in the installation site should be within the limits of the norm.
- Before connecting the device, make sure that the power supply meets the requirements of the controller.
- All devices connected to the controller must comply with its specifications.
- All actions performed with the open regulator must be accompanied by its disconnection from the power supply. All safety requirements when working with

a power source must be met. The connection and / or all actions that require opening the regulator (for example, replacement of a fuse) must only be performed by specialists.

To install the display panel proceed as follows:

-Remove the rear panel of the display by turning in the direction shown in figure 3.23;

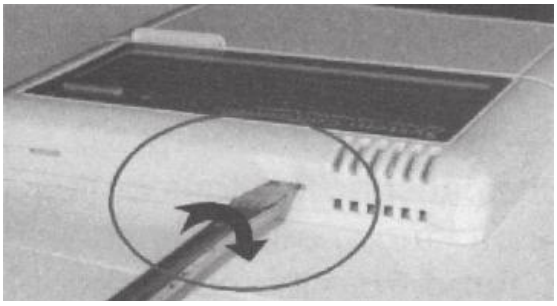


Figure 3.23 - Control panel (opening the lid). - Fix the rear panel with screws on the wall, do not drill holes on the controller (see Figure 3.24).

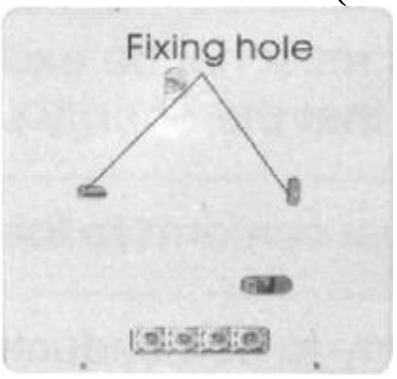


Figure 3.24 - The control panel (fasteners). -Install the top of the display into the holes (1), (2) on the rear panel, secure it (see figure 3.25).

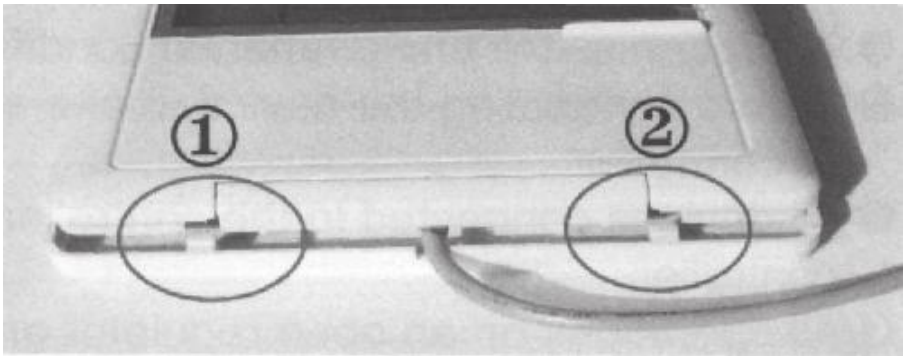


Figure 3.25 - Control panel (installation).

The controller must be installed only in the places having the correspondences.

Fastening the inclined panel of the controller.

- choose the appropriate place;

- Position the sloped panel on the wall and mark the location of the holes, taking into account the overall dimensions of the panel;

- Drill a hole and insert plugs in them;
- Believe the sloping panel;
- Securely fasten the controller to the panel.

Disconnect the device from the mains before opening. All applicable rules must be observed.

Opening and closing the terminal box:

- Loosen the screws (1), (2) and slide it up;
- Closing the lid: sliding down, close the lid;
- Secure with screws (1), (2).

Power can only be turned on when the controller is closed, the installer must ensure that the electrical protection of the controller is not broken during installation. Depending on the type of installation, the cable can enter the device through the rear wall or from below.

The cable fits behind (4) (5): remove the plastic flap from the back, using a suitable tool. The cable comes from below: cut the left and right flaps using a suitable tool (see Figure 3.25).

After connecting, place the cable in the channel and secure it with a plate (Figure 3.26). The pointer of the control panel terminals is shown in figure 3.27.

The designation and functions of the device, as well as the output and input connection contacts are presented in the table (3.2 - 3.3).

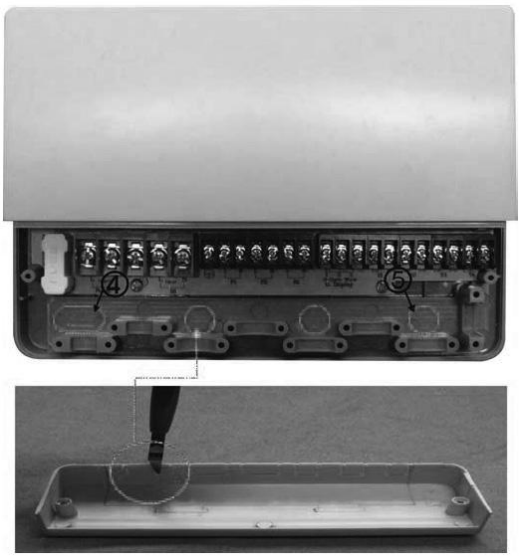


Figure 3.26- Control panel (switching, cable connection).

Table 3.2 - Designation and functions of the device.

Designation	Function Output contacts of the DHW circulation pump P2
T1	Input contact of collector temperature sensor T1
T2	Input contact of tank temperature sensor T2, bottom

T3	Temperature sensor input contact T3, top
T4	Hot water pipe temperature sensor input contact (option)
No:01	Display connection port
Power	Power Supply Input
Heating	Output contacts of electric heater H1
ΔT on /ΔT off	Output contacts for switching the circulation pump on ΔT, P1
Pipe circuit	Output contacts of the DHW circulation pump P2
Water input valve	It is used for the operation of the system for protecting against overheating of hot water in the tank, which has two internal heat exchangers

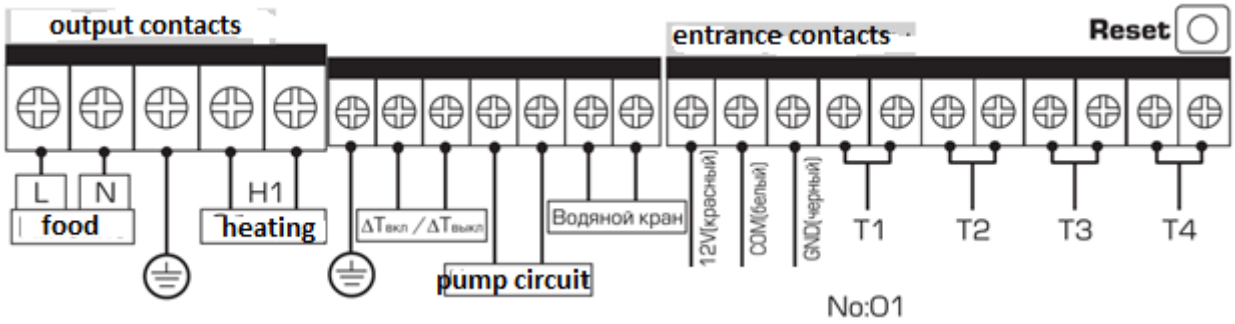


Figure 3.27 - Index of control panel terminals.

Table 3.3 - Output and input connection contacts.

Input contacts:	Output contacts:	Power connection:
1. Input T1, T2 and T3, (T4 option): sensors temperature. 2. Entrance No: 01 3-contact connector with display.	1. Outputs P1 and P2: Electromagnetic relays with a maximum current of 5A. 2. Output H1: Electromagnetic relays with a maximum current of 16A. 3. Output R1: water inlet valve, electromagnetic relays with a maximum current of 16A.	1. Remember that the type of supply voltage is indicated on the nameplate device. 2. The device must be is grounded.

Reset: This button is on the display panel, press the "Reset" button when the system is not working to restore the factory settings.

Only Pt1000 temperature sensors supplied by the manufacturer are suitable for working with the collector. They are equipped with a 1.5 m silicon cable and are suitable for all weather conditions. Temperature sensor and cable - resistant to temperatures up to 280 ° C, so there is no need to distinguish between positive and

negative polarity. Supplied only by the manufacturer NTC10K, B = 3950 temperature sensors are designed for use with a tank and pipe and are equipped with a 1.5 m PVC cable. They are resistant to temperatures up to 105 ° C, so there is no need to distinguish between positive and negative polarity.

All sensor cables transmit low voltage. To avoid interference, they should not be placed close to 230 V or 400 cables (minimum distance 100 mm). With powerful external sources of interference, such as a powerful cable, transformer substations, radio and television devices, amateur radio stations, microwave devices, the cable connecting the sensors must be securely screened.

The sensor cable can have a maximum length of up to 100 meters, with a cable length of up to 50 m, the cable cross-section should be at least 0.75 mm^2. With a cable length of up to 100 m, the cross-section of the cable must be at least 1.5 mm^2.

3.8 Assembling a solar water heater with vacuum tubes.

The goal is to acquire skills and skills in assembling the solar collector.

A solar water heater with vacuum tubes absorbs solar energy, turning it into thermal energy.

Due to solar energy, this system is able to provide up to 100% of the daily demand for domestic hot water for domestic and industrial purposes. Solar water heater is designed and manufactured in accordance with international standards, which ensures safety and reliability in operation.

The solar water heater of the system without pressure is the simplest of solar energy systems to provide hot water, does not need a pump to move the hot water flow, because it is located above the point or points of water analysis. If the solar water heater is installed below the point or points of analysis, a feed pump must be installed to supply water from the tank to the system.

The solar collector with vacuum tubes of the system without pressure is operated only in the warm season (at a positive temperature), during the winter period, the water from the system must be drained.

Short-term operation of the SVN during short-term frosts up to -3^oC is allowed.

The advantage of vacuum tubular solar collectors over flat ones is that they have greater efficiency at low solar radiation intensity, as well as diffusion radiation (no direct sunlight) and minimal heat loss. Solar water heaters are used to provide hot water in country houses.

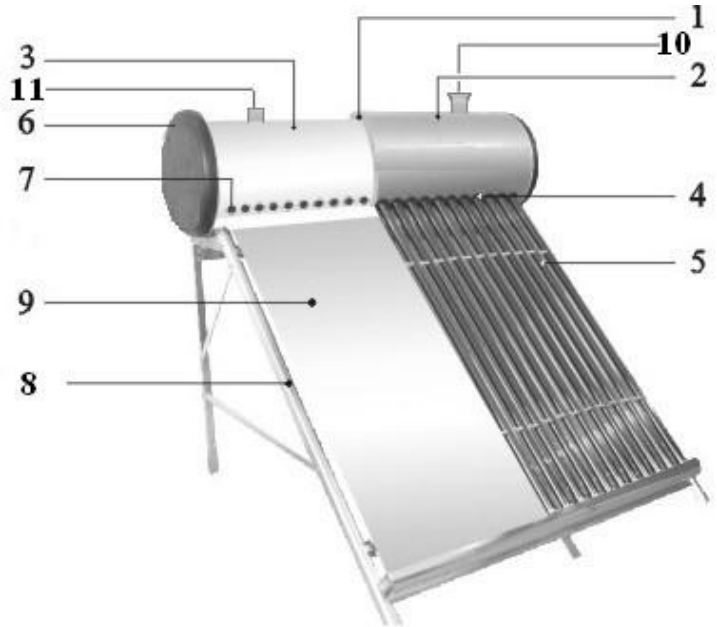
Collectors can be installed on roofs, which have sufficient margin of safety of the roof and floors. When installing on existing roofs, check that the roof and floors have sufficient margin to withstand additional weight. It is important that the structural capabilities of the roof and floors are checked at the installation sites before assembling the collectors.

Particular attention should be paid to the quality of the overlappings in terms of the stability of screw fixing, which is necessary for the installation of collectors.

In general, it is important to check the roof construction in the places where the collectors are installed to meet specific standards, especially in regions with heavy snowfalls and strong winds. The assessment should also take into account any special characteristics of a particular location that could lead to increased loads (for wind, aircraft, airflow or turbulence, etc.). The structure of the solar water heater is shown in Figure 3.28.

The collector battery should always be installed in such a way that any possible snow drifts do not reach the collectors. The distance from the edge of the roof must be at least 1 meter. The solar collector should be installed with a strong and strong fixation in a solid structure.

It is not recommended to install collectors on flexible strips laid under sections. This type of installation can lead to excessive wind vibration and subsequent damage. When planning the installation of the collector battery, it must be ensured that the method chosen for you to install manifolds, laying pipelines and the passage of pipes inside the building will not damage the structure of the roof, ceilings and walls. You must provide protection against the penetration of water into the building caused by wind pressure and precipitation in the form of rain or snow.



1 - water tank; 2 - the outer layer of the tank; 3 - inner layer of the tank; 4 - a sealant, anther; 5 - vacuum tubes; 6 - the cover of the water tank; 7 - rubber sealing; 8 - retaining frame; 9 - reflecting plate; 10 - bleed air valve; 11 - sensor of the controller.

Figure 3.28- Structure of the solar water heater

It is not necessary to connect the collector to ground in the building to protect against lightning. For installation on metal roofs or on roofs with metal

ceilings, a specialist consultation is required to protect against lightning. It may be necessary to ground collectors to a rod in the ground.

The grounding line must be laid outside the building. The earth of the rod must be connected to the main conductor of the building ground by a conductor with the same cross section. It is desirable to install diodes to protect the temperature sensor of the solar collector. This will protect your controller from a power surge caused by lightning.

Collectors should be connected to each other by a main pipeline using threaded connections. Soldering on solar collectors is not recommended because of potential damage. The collector has a 1-inch nozzle at the inlet and outlet.

Precautions must be taken to protect the connecting pipes from temperature fluctuations caused by thermal expansion.

No more than 6 collectors (20 R) or 4 collectors (30 R) can be connected in series without using expansion links to connect the collectors together.

The collector should be installed in the corners between 15 and 75. This is necessary for optimal operation of the vacuum tube.

The temperature sensor must be installed in the sensor socket at the collector nearest to the beginning of the flow. In order to ensure optimum contact between the sensor and the socket, lubricate the sensor element with a heat-conducting paste. All materials used to install temperature sensors (sensor element, cable, thermal conductive paste, gaskets and thermal insulation) must be heat resistant up to + 250 ° C.

It is advisable to install the IP65 with overload protection diodes. These diodes will protect your controller from voltage peaks caused by lightning.

For safety reasons, fill the collector circuit only when there is no direct sunlight (or the collector is covered). In regions prone to frosty winters, you should use a prepared antifreeze with anti-corrosion additives.

It is not possible to completely drain the fluid from the collectors if they have been filled. Collectors exposed to frost should be filled only with antifreeze, even for crimping and functional tests.

It is recommended to fill the system under pressure with a filling pump to remove air bubbles and plugs from the collector's battery and the solar circuit (Figure 3.29).

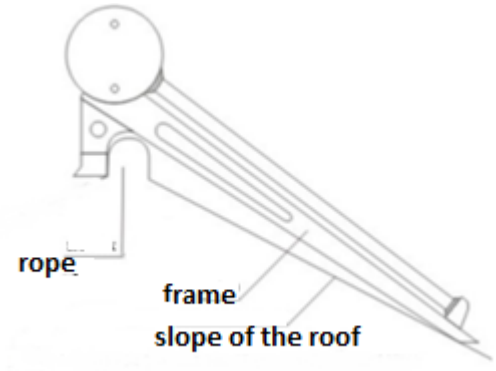


Figure 3.29 - Installation of the tank on the frame.

The maximum test pressure is 10 bar. The nominal operating pressure is 6 bar. Air must be removed from the system at the first start-up of the system (after filling the system / collectors) or if there are disruptions in operation due to air plugs. You can not work with a solar water heating system, when the coolant has a high temperature due to the risk of scalding. It is necessary to cover the collectors with covers and wait until the coolant in the system cools down. Work with the air valve at a coolant temperature of <60 ° C.

It is recommended to fill the system (collector battery) with antifreeze as a coolant. The condition of the coolant must be checked every two years for the freezing point and the pH value.

Using an antifreeze tester, check the freezing point of the coolant. If the value is less than -20 ° C, replace the antifreeze. If the pH value is less than 7, the heat medium must be replaced.

The collector or collector battery should be inspected visually, once a year, to detect any damage, leaks or damage. With visual inspection, each vacuum tube must be inspected (figure 3.31) to ensure vacuum integrity. If the base of the tube is silvery, then the vacuum is normal. If the base becomes white or transparent, then the vacuum is lost and the tube must be replaced.

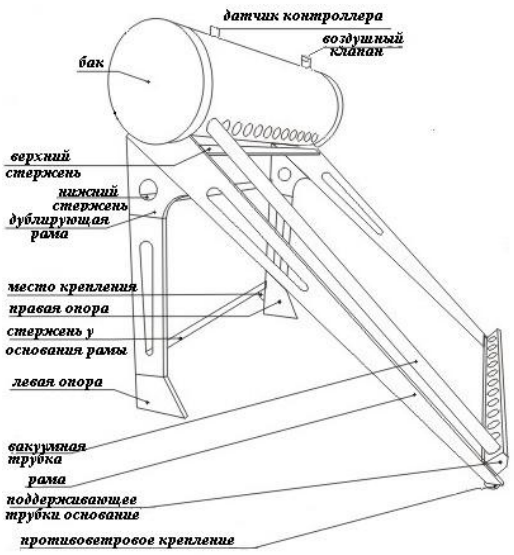


Figure 3.30 - Installation of the supports of the left and right supports.

Figure 3.31 - Composition and operating principle of vacuum tubes.

The design of the vacuum tube is similar to the construction of a glass thermos flask. Vacuum tubes can be single-layered and with a three-layer coating. Three-layer vacuum tubes have a high degree of absorption and high thermal stability.

They connect to the water tank above them. When the water in the tubes heats up, the density decreases and the water rises - into the tank. Cold water from the tank flows downwards - into the vacuum tube. This ensures water circulation and heat exchange of the entire system (Figure 3.32).

Vacuum tubes are made of high-quality, heavy-duty borosilicate glass, which provides protection from hail and mechanical damage.

Prepare the pipes for connection to the collector manifold (Figures 3.32 - 3.34). For this:

- It is necessary to apply a thin layer of heat-conducting paste to the condenser of the heat pipe;

- Then apply soapy water to the vacuum tubes, as shown in the figure.

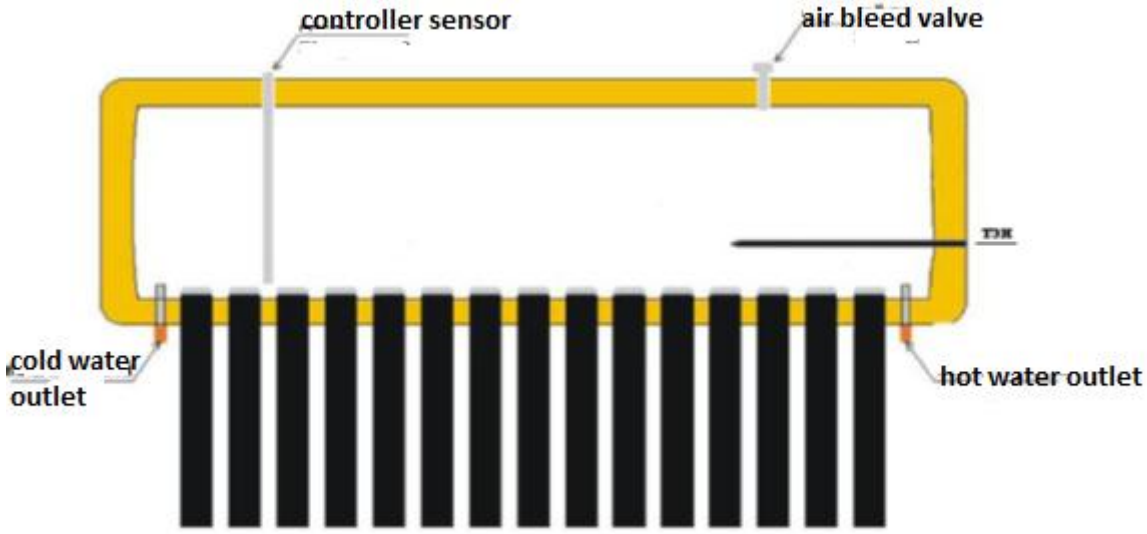


Figure 3.32 - Tank connection elements.

Figure 3.33 - Preparing for installation.

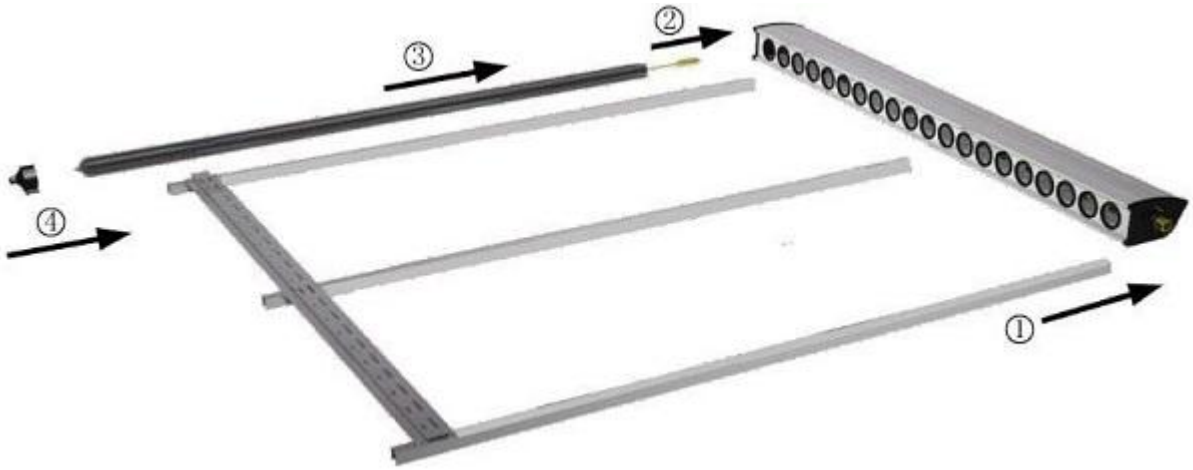


Figure 3.34 - Installation of vacuum tubes.

Using rotary movements, place the tube in the collector manifold, place the support cup under the end of the tube on the latches.

Assembling the solar collector. In order to assemble the manifold, simply connect the frame sections and the base to each other using nuts and bolts M6. Then attach the frame sections to the manifold using the provided bolts, these bolts are screwed onto the rear wall of the manifold. As soon as this step is completed, you can strengthen the collector on a stand and install it using the appropriate method.

When there is a collector installed on the frame in the right place, it is desirable to make a piping with a sanitary fixture and fill the system. When the system is ready for operation, it is possible to install tubes. Pipes can be inserted into the manifold before the assembled collector is installed, but it is extremely important to remember when working to potential heat transfer through the tubes and be very careful.

After the system is full and operational, check all manifold connections and piping for leaks.

3.9 Installing the solar water heater.

The goal is to acquire the skills to install a solar collector depending on the solar resources and the type of terrain facilities.

Selection of the location of solar collectors. Before installing a solar water heating system, you must first consider the solar resources of the latitude of your terrain, since the efficiency and design of solar water heating systems depend on how much solar energy reaches the construction site.

Solar collectors can be installed on the roof, on the walls of the house and even on the ground.

The area of the installation is unshaded from dawn to dusk and comes to the south, (for northern latitudes) is an ideally good candidate for solar water heating systems. In addition, it is necessary to consider factors such as the orientation of the roof, local features of the landscape, which can obscure it. If the

roof is properly oriented with a sufficiently unsharpened area and surface and do not need to be replaced in the near future?

There are a number of different types of systems and components that differ from manufacturer to manufacturer. Each house looks a bit different, and getting plumbing from the collectors to the reservoir may require the removal of plaster rocks or roofing sheets, which then need to be replaced. It is possible to encounter construction and finishing works before starting the system.

Can the roof maintain the solar collector's own weight and the load of the installation (if the roof is chosen for the installation of the system). Is there a place in the building for the buffer tank, the indirect heating tank and the corresponding hardware. The coolant distribution lines may be installed between the storage tank and the solar collector without significant reconstruction efforts.

When installing manifolds, several roof penetrations are made, as possible. In some cases, collectors can be installed on the roof and pipelines run through a vertical wall, rather than through a roof. Different manufacturers supply different sets of fasteners for the installation of collectors on the roof.

It is necessary to find roof rafters, to which collectors will be attached. Rafters are 16 inches or 24 cm from the center to the center. If it is not possible to attach the collector frame to the rafters, you need to install a block between the rafters and mount the equipment for the manifold. The roofing does not give the necessary support to the solar collectors. It is necessary to ensure that the solar collectors and mounting equipment are securely attached to the supporting structures. Fill all the slots and penetrations of the roof with silicone sealants.

Install a buffer tank (heat accumulator) and an indirect heating tank next to conventional water heaters. Collectors and all installations of the system must be connected to each other by a main pipeline using threaded connections. Soldering on solar collectors is not recommended because of potential damage. If it is not possible to use flexible corrugated pipes as connecting elements, precautions must be taken to protect the connecting pipes from temperature fluctuations caused by thermal expansion.

Installation of feed and return lines of the system. In most solar water heater systems, the piping for the coolant is no more than ½ inch. It is necessary to connect all the lines, without solder, using threaded connections. This installation, gives an advantage in the case where, some node needs to be replaced, can be replaced without cutting the pipes.

The circulation pump must be installed in the lowest part of the hinge. The non-return valve must be installed at the pump outlet, so that when the pump is turned off, the glycol will not flow backwards. The expansion vessel must be installed with a pressure gauge to monitor the pressure in the system.

The safety valve should be located in places accessible for maintenance, installation and dismantling. As a rule, vertical vessels should be installed on the upper bottom, and on horizontal vessels and pipelines it should be installed on the top generatrix of the cylinder, i.e. in the zone of the gas (vapor) phase.

The safety valve should be installed on vessels, pipelines in places that exclude the formation of hydraulic "bags" and stagnant zones. The output from the

safety valve must be connected to the drain. The ball valve is installed to control the flow to the circuit. Thermometers at the inlet and outlet of the heat exchanger will help monitor system performance.

The differential controller must be installed to determine the temperature difference between the water in the bottom of the solar tank and the glycol at the top of the solar collectors. The controller performs intelligent control and automatic operation of the system: it regulates the level of water in the tank (opens the water supply valve from the water pipe), maintains the specified parameters for the temperature of the liquid heating in the tank (in the electric system equipped with a tenon, it includes an electric heater with insufficient solar water heating). The temperature sensor of the controller should be covered with a thick layer of thermal paste and inserted into the installation hole to full depth. If the sensor is too loose, insert a piece of copper plate or wire near the sensor, cover the sensor hole with silicone sealants to prevent water from entering the sensor. Make sure that the sensor used on the manifold can measure the temperature to 250 ° C and has a suitable cable. The bypass valve is installed to control the flow of the coolant in the solar collector. Allows you to set the desired speed of the coolant and significantly increase the efficiency of solar heating. The solar system should operate at a pressure not exceeding 5 bar with a pressure limiting valve. The system must be assembled in such a way that, at a pressure of more than 8 bar, excess pressure occurs and also hot water from the storage tank or system when the temperature reaches 100 ° C. It is recommended to check the valve every 6 months for proper operation.

Refueling and crimping of the system. It is necessary to check the coolant circuit for leaks and water. The circulation pump is likely to be too small to fill the system, so a pump is needed that can provide sufficient pressure to press the system 6bar for 48 hours. If the pressure in the circuit has dropped, you have leaks that need to be found and repaired. If the pressure is held, it is necessary to fill the system with antifreeze (ethyl alcohol solution 50%).

After the system has been checked for leaks, all lines of the coolant must be carefully insulated. The water supply can be insulated with standard pipe insulation. Pipelines for glycol and external heat exchangers should be insulated with fiberglass pipe insulation. Adhesive tape can be used on the joints of the water pipe insulation and use a joint tape that comes with fiberglass pipe insulation. The insulation can be protected by a foil or UV-resistant paint.

3.10 Prospects for the development of a solar thermal device.

The goal is to acquire the skills to install a solar collector depending on the solar resources and the type of terrain facilities.

With the help of solar collectors, the consumer receives heat and hot water at a "zero tariff". The heat collector gives out literally at zero tariff. With the dynamic growth of tariffs for energy carriers, which has been observed recently, the solution of the issue of hot water supply and heat supply of almost any objects,

regardless of their purpose and volume due to the transformation of the energy of solar radiation, is becoming more urgent. New terms and definitions have appeared. Systems that convert solar energy into heat and electricity have been called solar solar systems.

The energy radiated by the sun and reaching the surface of the Earth - sunlight is the largest energy source available on Earth. The amount of heat supplied per year per 1 sq. Km. m of the Earth's surface, is estimated at 3.16x109 KJ. In other words, the amount of solar energy available for use is 20000 times higher than all the combined energy sources used by mankind. These factors make application of solar collectors more and more attractive.

The production of installations for the use of solar energy, over the past 4 years, has increased several times. Experts, analyzing the experience of using solar collectors, suggest that by 2020 solar energy will satisfy (15 - 20) % of people's energy needs. To date, more than 3 million solar systems are put into operation [4].

The statistics were obtained not only at the expense of countries with a warm climate. Experience shows that the effectiveness of solar collectors and proved in the climatic conditions of the North. Solar collector systems have different designs and are suitable for all types of climate. Modern water heating systems on solar collectors have controllers in their composition that automatically maintain optimal circulation parameters of the coolant, have antifreeze mode and provide, for example, a set room temperature or water temperature for domestic needs. In the absence of sufficient solar activity, the controller may include an additional electric heater installed in the heat accumulator. The cost of the controller can be less than 10 dollars.

The performance of the water heating system on solar collectors depends on the parameters of solar radiation in a particular region. The intensity of solar radiation in our region - the middle belt, where about 300 sunny days per year, allows to ensure high productivity of solar collectors.

Technical and economic calculations based on the experience of operating solar collectors, that is, on existing systems on solar collectors, show that at existing prices for organic fuel, the payback period of solar plants on solar collectors, taking into account operating costs, is from 2 to 5 years with a service life of (25-30) years or more. At the end of the payback period, the result of the application of solar collectors is 20 to 25 years of free energy produced by the solar installation. In addition to the economic effect, solar power plants are environmentally friendly sources of energy.

The field of application of solar collectors is extensive - these are cottages, cottages, open and closed swimming pools, small autonomous shops, restaurants, cafes and other public catering points, mobile socially oriented points, greenhouses and so on - almost everywhere where there is cold water and daylight.

Solar collectors - water heaters allow to solve problems with provision of hot water for various purposes:

- autonomous hot water supply for domestic purposes;
- support for full or on-site heating for premises;

- optimization of existing systems of hot water supply and heating due to energy saving;

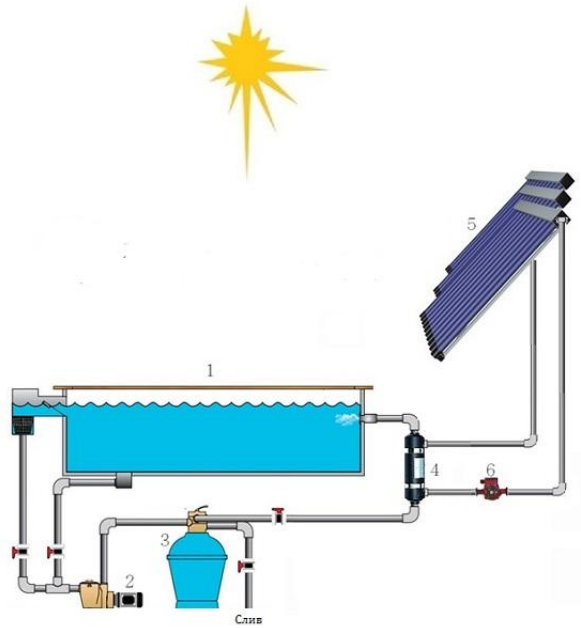
- heating - maintaining the set water temperature in closed or open pools;

-Heat warming.

Advantages of heating systems on solar collectors: a significant reduction in costs for hot water supply, heating the house or any other object, reducing the annual cost of heating water by 60%, heating - by 30% per year, the autonomy of the energy source, which is converted into heat - energy of the Sun increase the service life of the existing heating system - an existing boiler or gas boiler by 2 times, by reducing its load to 97%, easy integration into the existing system of heat supply and hot water supply ecologist chnost safety of human health due to the lack of polluting components.

Solar pool heating, is one of the simplest and most effective ways, using solar energy.

Solar collectors are easily integrated into the circulation cycle of water purification, and it makes it possible to maintain an acceptable temperature in the pool, both in summer and in winter (Figure 3.35). It should be noted that the efficiency of the system depends on the area of the solar collectors and the volume of the pool, but in any case when using solar heat you do not pay anything for heating your pool, unlike standard heating systems.



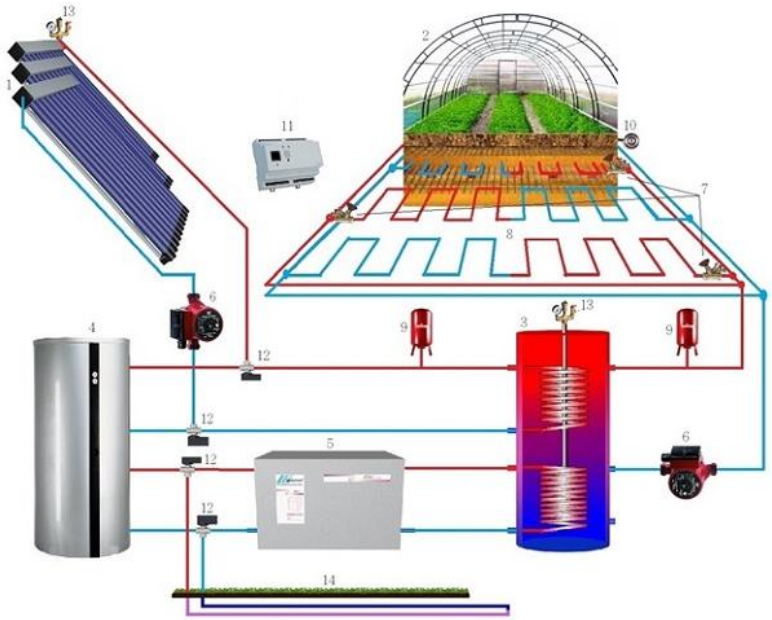
1. Drain pool, 2. Pump, 3. Water purification filter, 4. Water-water heat exchanger, 5. Solar collectors, 6. Circulation pump.

Figure 3.35 - Collector pool heating:

For indoor pools, from April to September, the vacuum collector system provides 100% coverage of the pool load. In the rest of the time the percentage of coverage decreases and it is necessary to use an auxiliary source of thermal energy "Heat pump".

Installation of the solar power system can be planned even at the stage of construction of a house or other facility. Experience shows that this simplifies installation and operation of solar collectors. It is possible to connect the heating system to the solar collector and to the existing heat supply system. In the latter case, instead of a traditional boiler, a solar energy boiler is installed - a storage tank of the solar collector, and a coolant that receives heat from the solar collector is used as a source of hot water.

The heating system on solar collectors is ideally suited to the system of water heated floors and the heating of swimming pools. Especially effective utilization of solar energy is combined systems that use solar collectors together with heat pumps. Among all types of solar collectors, the most popular are flat collectors and collectors on vacuum tubes. Due to high thermal insulation, vacuum solar collectors work very efficiently at low ambient temperatures. Solar vacuum collectors remain operational in the cold season to -30C, which makes them very useful for heating greenhouses and soil (Figure 3.36).



1.Solnechnye collectors, 2.Teplitsa, 3.Boyler indirect heating, 4.Bak heat accumulator, 5.Heat pump, 6.Circulation pump, 7.Valves flow regulators, 8.The heating of the greenhouse (it is the same as the heat accumulator), 9.Hydraulic accumulators, 10.Sensor of humidity and soil temperature, 11.Logic controller, 12. Three-way running cranes with servo drives, 13. Safety group, 14.Geothermal circuit.

Figure 3.36 - Diagram of a collector block of heat-fed greenhouses

However, in the winter season, when the ambient temperature and the solar radiation flux density are low, they are not able to provide the consumer on their own, then a heat pump is connected. Union of combined systems, is competitive in comparison with traditional heating systems. Due to the lower cost of the devices, this heating path becomes very attractive. Solar energy is free, environmentally friendly and can cover a significant share of the heat demand of the greenhouse.

The use of solar collectors can reduce the cost of heating hot water by 60%, heating costs by 30% per year. Economic calculations based on the experience of operating solar collectors show that with existing and constantly rising prices for organic fuels, the payback period of solar collectors is 2 to 5 years, while, according to the producers, their real life is 25 -30 years, and according to some manufacturers and more than 30 years.

Another positive point is that the system with a drain into the thermos allows without problems to use several solar collectors oriented at different angles to the plane of motion of the Sun. For example, to the south-east and south-west. Then in the morning the eastern collector will begin to heat the water, in the afternoon both will work, and in the afternoon - the western one. To obtain higher operating temperatures, solar tracking devices are required.

3.11 Conclusions on the chapter

On the basis of the studies carried out, the chapter shows the following:

- the operation principle of the "Wind-up" type equipment with a horizontal and vertical axis of rotation;
- The advantages of analyzing existing "wind turbines" and the possibility of including them with a block of different batteries are shown;
- the basic principles of the choice of the wind farm and the factors influencing the choice of a different type of wind turbine are shown;
- service and basic requirements for the installation of wind turbines are shown;
- in the section the table of malfunctions in the vetoustanovka and methods of their elimination is given;
- The wind turbine-type wind turbine with a total capacity of 5 kW installed on the "Training ground" has been introduced at the department;
- the procedure of operation of wind-driven wind turbines is shown;
- the principles of operation of equipment such as "Solar thermal device";
- The analysis of heat accumulators of internal and external type is given;
- Various assemblies of the solar water heater with vacuum tubes and the possibilities of their use are given;
- The structure of the solar water heater, the composition and advantages of vacuum tubes;
- the skills for installing a solar collector are shown depending on solar resources and conditions on the territory of the university;
- the basic prospects of development of the solar thermal device are given;
- solar water heaters of an open and closed type are introduced into the educational process at the EEiTE chair.

4 Safety in working with renewable energy

4.1 Safety instructions for installing a wind power plant

When planning the location, installation and operation of the generator, you must first think about security [15]. Never forget the dangers of mechanical and electrical devices and rotor blades.

Mechanical hazards Rotating blades are the most serious mechanical source of danger. The blades of the rotor of the wind generator are made of a very strong thermoplastic. The speed of the tip of the blades exceeds 400 km / h. At this speed, the tips of the blades are almost invisible and can cause serious injury. Under no circumstances should the generator be installed in places where it is possible to contact the person with the moving blades of the rotor.

Electric sources of hazards The wind generator is equipped with sophisticated electronic devices, the development of which provided protection against electrical sources of danger associated with excessive currents [20]. When connecting these and any other electrical devices, remember that the inevitable risks created for people by the flow of electrical current, still exist. Heat release in electrical installation systems is often the result of excessive current flowing through wires with insufficient cross-section or through bad contacts. Batteries can throw out dangerous currents. In the event of a short circuit in the wires coming from the battery, a fire may occur. To eliminate this risk, it is necessary to install fuses or circuit breakers of the appropriate rating in the circuits connected to the battery.

4.2 Safety regulations for operation of a wind power plant

The operation of a wind turbine shall be organized in such a way as to ensure its energy, technical and cost-effective operation [15]. The guarantee of the quality of operation of the windmill is an integral part and the result of the aggregate quality assurance of the design, construction, production, supply, management, operation and maintenance of the windmill and all its components.

The quality assurance is an integral part and the result of the set of quality assurance of design, construction, production, management, operation and maintenance of wind turbines and all its components.

On the basis of SRT 000-00p.2.22 and the operating instructions for equipment on the windmill, local regulations should be developed.

Knowledge of the mandatory standard is mandatory for personnel involved in the development, harmonization and approval of local operating instructions.

Knowledge of local regulations compiled on the basis of this standard is mandatory for the consumer.

When operating the windmill, a safe, reliable and economical mode of operation of the wind turbine equipment must be provided in accordance with the operating instructions for the equipment, the uninterrupted operation of the

equipment in permissible modes, the reliable operation of the monitoring, protection and automation devices.

The consumer who manages the windmill must be located at ground level.

It is allowed to place the control panel of the wind farm in a room suitable for operating conditions of the wind turbine, provided that quick access is provided to repair the wind turbine.

Preventive testing of wind turbines must be organized in accordance with the instructions for the operation of electrical equipment.

Current repair of wind turbine equipment and also check of its actions to produce as required, depending on their purpose and technical condition.

Wind power plant - a complex technical device, combining the aerodynamic and electrical parts [20]. The slightest non-compliance with the assembly of the wind turbine or its operation can lead to its breakdown and causing both material damage and harm to health, as well as people nearby.

It is necessary to completely isolate the connected wires and cables.

At the first start-up of the windmill, it is necessary to monitor the operation of the windmill for 2-3 hours and to pay attention to possible vibrations, knocking, clapping, which indicates the malfunction of the windmill and immediately stop it.

It is forbidden to make the first start of the wind turbine at a wind speed of more than 5 m / s (corresponds to the average wind).

It is forbidden to make constructive and adjusting changes to the design of wind turbines.

Do not apply any voltage to the generator to start it. It is forbidden to connect any outputs of the generator and the OEZA unit to the electricity network or any other source of electricity.

It is necessary to take a set of measures to protect the windmill from lightning.

4.3 General

The work of operators, programmers and just users is directly connected by computers, and accordingly with additional harmful effects of a whole group of factors, which significantly reduces the productivity of their work.

The study and solution of problems related to the provision of healthy and safe conditions in which human work is taking place is one of the most important tasks in the development of new technologies and production systems. The study and identification of possible causes of industrial accidents, occupational diseases, accidents, explosions, fires, and the development of measures and requirements aimed at eliminating these causes make it possible to create safe and favorable conditions for human labor.

Comfortable and safe working conditions are one of the main factors affecting the performance of people working with PC.

PC significantly simplifies the process of office work. It is necessary to know: GOSTs, standards, requirements, recommendations, compatibility, environmental safety, etc.

4.4 Requirements for monitors (VDT) and a computer

The design of the monitor (video terminal device - VDT) should provide for the possibility of front-line surveillance of the screen by rotating the housing in a horizontal plane around the vertical axis within ± 30 ° and in a vertical plane around the horizontal axis within ± 30 ° in a fixed position. The design of monitors should provide for coloring in calm soft tones with diffuse light scattering. The case of the monitor and PC, the keyboard should have a matte surface of the same color with a reflection coefficient of 0.4 to 0.6 and not have shiny details that can create glare.

The design of the VDT should include the presence of brightness and contrast control knobs, providing the ability to adjust brightness and contrast, allowing the adjustment of these parameters from minimum to maximum values.

VDT and PC should provide the power of the exposure dose of X-rays at any point at a distance of 0.05 m. from the screen and the monitor housing at any position of the adjusting devices should not exceed 7.74x10 A / kg, which corresponds to an equivalent dose of 0.1 mrem / hour (100 mcR / h).

The monitor must meet certain requirements and standards. Requirements for monitors are divided into two main groups of standards and recommendations - security and ergonomics.

The first group includes the standards UL, CSA, DHHS, CE, Scandinavian SEMRO, DEMCO, NEMCO, and FCC Class B. The second group is best known for MPR-II, TCO'92, TCO'95, ISO 9241-3, EPA Energu Star, TUV Ergonomie.

Monitors for personal computers and workstations with mandatory certification tests for the following parameters:

1. Safety parameters - electrical, mechanical, fire safety (GOST R 50377-92).

2. Sanitary and hygienic requirements - the level of sound noise (GOST 26329 - 84 or GOST 2718 - 88), ultraviolet, X-ray radiation and image quality indicators (GOST 27954 - 88).

3. Electromagnetic compatibility - radiated radio interference (GOST 29216 - 91).

The surface of the floor in the premises of the operation of monitors and the PC must be level, without potholes, non-slip, convenient for cleaning and for wet cleaning, and have antistatic properties.

4.5 Requirements for rooms for the operation of monitors and PCs

The room with monitors and PC must have natural and artificial lighting. Natural illumination should be carried out through light barriers oriented mainly to the north and north-east to provide a natural light factor (KEO) of not less than 1.2% in zones with a stable snow cover and at least 1.5% in the rest of the territory. These KEO values are normalized for buildings located in the III light climatic zone.

The area for one workplace with VDT or PC for adult users should be at least 6.0 m2, and a volume of at least 20.0 m^3

For interior decoration of premises with monitors and a PC, diffuse reflective materials with a reflectance for the ceiling should be used - (0.7-0.8); for walls - (0,5 - 0,6); for the floor - (0,3 - 0,5).

When performing basic work on monitors and PCs (dispatching, operator, accounting, control cabins and cabins, computer rooms, etc.) where engineers and technicians perform laboratory, analytical or measurement control, the noise level should not exceed 60 dBA.

In the premises of computer operators (without displays), the noise level should not exceed 65 dBA.

At workplaces in the rooms for placing noisy aggregates of computers (ATSPU, printers, etc.), the noise level should not exceed 75 dBA.

Noisy equipment (ATSPU, printers, etc.), the noise levels of which exceed normalized, should be out of the room with a monitor and a PC.

Artificial lighting in the premises for the operation of monitors and computers should be carried out by a system of general uniform illumination. It is allowed to use local lighting designed to illuminate the location of documents.

Illumination on the surface of the table in the area where the working document is placed must be (300 - 500) lux. It is allowed to install local lighting fixtures to illuminate documents. Local lighting should not create glare on the surface of the screen and increase the illumination of the screen by more than 300 lux.

To illuminate rooms with monitors and PCs, it is necessary to use lamps of the LPOZB series with mirror gratings, equipped with high-frequency ballasts (HF ballasts). It is allowed to use the LPOZB series without HF gear only in the modification "Kososvet", as well as the direct light fixtures - P, the predominant light - H, the reflected light - V. The use of luminaires without lenses and shielding gratings is not allowed.

The brightness of general lighting in the area of the emission angles from 50° to 90° with vertical in the longitudinal and transverse planes should not exceed 200 cd / sq. m, the protective angle of the luminaires should be at least 40°.

The luminaires of local lighting must have a non-translucent reflector with a protective angle of at least 40 degrees.

Workplaces with VDT and PC with respect to light projects should be located so that natural light falls from the side, mainly on the left.

The layouts of workstations with VDT and PC must take into account the distances between the work tables with video monitors (in the direction of the rear of the surface of one video monitor and the screen of another video monitor), which must be at least 2.0 m, and the distance between the side surfaces of video monitors - at least 1, 2 m.

Window openings in the use of VDT and PC should be equipped with adjustable devices such as: blinds, curtains, external visors, etc. The monitor screen should be at a distance (600-700) mm, but not closer than 500 mm from th alphanumeric characters and symbols.

Premises with VDT and PC must be equipped with a first-aid kit and carbon dioxide fire extinguishers.

4.6 Potentially hazardous and harmful production factors

Currently available in our country, a set of organizational measures and technical protection measures developed, the accumulated advanced experience of a number of computer centers (VCs) shows that it is possible to achieve much greater success in eliminating the impact on working dangerous and harmful production factors.

Medical examinations of workers in the CC showed that, in addition to reducing productivity, high levels of noise lead to a worsening of hearing. Long-term presence of a person in the zone of combined exposure to various adverse factors can lead to occupational disease. The analysis of injuries among workers of the Computer Center shows that mainly accidents occur from the impact of physically dangerous production factors when refilling the information carrier on a rotating drum with the case removed, when employees carry out works that are not their own. In the second place, the cases associated with the impact of electric current.

4.7 Ensuring electrical safety

Electrical installations, which include almost all computer equipment, present a greater potential for a person, since during operation or carrying out preventive work a person can touch parts that are under stress. The specific danger of electrical installations: current-carrying conductors, computer cases and other equipment that has been energized as a result of insulation damage (breakdown), do not give any signals that warn the person of danger. The reaction of a person to an electric current arises only when the latter passes through the human body. Exceptionally important for the prevention of electrotraumas is the correct organization of maintenance of existing electrical installations of the Computer Center, carrying out repair, installation and maintenance work. At the same time, the right organization means the strict implementation of a number of organizational and technical measures and facilities established by the current "Rules for the technical operation of consumer electrical installations and safety rules for the operation of consumer electrical installations" (PTE and PTB consumers) and "Rules for the installation of electrical installations" (PUE).

With PTE and PTW, consumers and maintenance personnel of electrical installations are subject to the following requirements: persons under the age of 18 could not be allowed to work in electrical installations; persons should not have injuries and illnesses that interfere with productive work; persons should, after appropriate theoretical and practical training, pass a knowledge test and have a certificate of access to work in electrical installations.

4.8 Provision of sanitary and hygienic requirements to the premises of computer centers.

VC premises, their dimensions (area, volume) should, first of all, correspond to the number of working tools and the set of technical equipment placed in them. They provide the appropriate parameters for temperature, lighting, air purity, provide insulation, from production noise, etc. To ensure normal working conditions, sanitary norms CH 245-71 are set for one worker, the volume of the production room is not less than 15 m^3, the area of the building is not less than 4.5 m^3, which is walled or blinded by partitions.

For computer operation, the following premises should be provided: a computer room, a room for placing service and peripheral equipment, a room for storing spare parts, tools, instruments (SPTA); premises for placing supply and exhaust fans; staff accommodation; premises for receiving and issuing information.

The main premises of the EC are located in close proximity to each other. They are equipped with general ventilation and artificial lighting. Special requirements are placed on the room of the computer room and the storage of magnetic media. The area of the computer room must correspond to the area of the computer necessary for the factory specifications of this type of computer. Artificial lighting by the nature of the tasks performed is divided into working, emergency, evacuation.

Reducing noise generated at workstations by VCs from internal sources, as well as noise from outside, is a very important task. Reduction of noise in the source of radiation can be ensured by applying elastic gaskets between the base of the machine, the instrument and the supporting surface. As the gaskets, rubber, felt, cork, various designs of shock absorbers are used. Under the table noisy apparatuses, soft mats made of synthetic materials can be laid, and under the feet of the tables on which they are installed, there are gaskets made of soft rubber, felt, with a thickness of (6-8) mm. Fastening of gaskets is possible by gluing them to the support parts. Reducing the level of noise penetrating into the production room from the outside can be achieved by increasing the sound insulation of enclosing structures, sealing around the perimeter of the gates of windows and doors.

4.9 Fire protection

Fire in the EC poses a particular danger, as they are associated with large material losses. A characteristic feature of the CC is the small areas of the premises. As is well known, a fire can occur during the interaction of combustible substances, oxidation and ignition sources. In the premises of the CC there are all three main factors necessary for the occurrence of a fire.

The combustible components on the CC are: building materials for acoustic and aesthetic finishing of rooms, partitions, doors, floors, punched cards and punched tapes, insulation of cables, etc.

Fire protection is a complex of organizational and technical measures aimed at ensuring people's safety, preventing fire, limiting its spread, as well as creating conditions for successful fire fighting.

In modern computers very high density of the arrangement of elements of electronic circuits. In the immediate vicinity of each other are the connecting wires, cables. When an electric current flows through them, a considerable amount of heat is released. It is possible to reflow insulation. To remove excess heat from the computer are ventilation and air conditioning systems. With constant action, these systems represent an additional fire hazard.

The fire hazard of engine-generator sets is due to the possibility of short circuits, overloading, electric arcing. For safe operation, the correct calculation and selection of protection devices is necessary. In the behavior of maintenance, repair and maintenance work, various lubricants, light-alloyed fluids are used, temporary electrical conductors are laid, soldering and cleaning of individual components are carried out. There is an additional fire hazard requiring additional fire protection measures. In particular, when working with a soldering iron, it is necessary to use a fireproof stand with simple devices to reduce the power consumption when not in use.

For most of the premises of the CC there is a category of fire hazard B. Fire extinguishing means intended for localization of small fires include fire trunks, internal fire water pipes, fire extinguishers, dry sand, asbestos blankets, etc.

In the buildings of the CC, fire cranes are installed in the corridors, on the stairwell and entrance areas. Water is used to extinguish fires in the premises of programmers, libraries, auxiliary and office spaces. The use of water in computer rooms, computers, information storage facilities, control room facilities because of the danger of damage or complete failure of expensive equipment is possible in exceptional cases when the fire takes a threateningly large dimensions. At the same time, the amount of water should be minimal, and the computer devices must be protected from water ingress, covering them with a tarpaulin or cloth.

Fire extinguishers are widely used for extinguishing fires in the initial stages. By type of extinguishing agent used, fire extinguishers are divided into the following main groups.

Foam extinguishers are used to extinguish burning liquids, various materials, structural elements and equipment, other than live electrical equipment.

Gas extinguishers are used to extinguish liquid and solid substances, as well as electrical installations that are under voltage.

In the production premises of the CC, mainly carbon dioxide fire extinguishers are used, the advantages of which are the high fire extinguishing efficiency, the safety of electronic equipment, the dielectric properties of carbon dioxide, which makes it possible to use these fire extinguishers even in the event that the electrical installation can not be disconnected immediately.

The effectiveness of the application of APS systems is determined by the correct choice of the type of detectors and the locations of their installation. When choosing fire detectors, it is necessary to take into account the specific conditions of their operation: the features of the room and the air environment, the availability

of fire materials, the nature of the possible combustion, the specifics of the process, etc.

Objects VC except APS should be equipped with installations of stationary automatic fire extinguishing. It is most advisable to use a gas extinguishing installation in the CC, whose action is based on the rapid filling of the room with a fire-extinguishing gas substance with a sharp decrease in the oxygen content in the air.

CONCLUSION

On the basis of the studies carried out, the manual shows:

- the wind power installation of the hybrid "sun-vtore", power of 5 kW is introduced into the educational process;
- a solar thermal device was introduced;
- the procedure for introducing the "solar thermal device" into the educational process, with a power of 3 kW;
- the meteorological station has been introduced into the educational process with the possibility to take readings on 17 different components;
- The photovoltaic element of the open and closed type for 100l and 200l has been introduced into the educational process;
- the scheme of inclusion of solar panels and possibility of carrying out of experimental researches at a consecutive and parallel connection is resulted;
- the choice of charging regulators for a solar thermal device and the possibility of selecting an inverter and a system controller for solar panels;
- provides theoretical information on the role and purpose of a Davis Vantage Pro 2 meteorological station and the display of a program such as Weather Link, when a weather station is connected to a computer;
- Experimental temperature studies obtained with the help of the Davis Vantage Pro 2 meteorological station are shown and temperature plots are shown for a different period of time on the territory of the university;
- The advantages of analyzing existing "wind turbines" and the possibility of including them with a block of different batteries are shown;
- the basic principles of the choice of a wind installation with a vertical and horizontal axis of rotation are shown, the factors influencing the choice of a wind generator, the main requirements for the installation of wind turbines and a table of faults in a wind farm and how to eliminate them;
- the principles of operation of the "Solar thermal device" are given, the analysis of internal and external heat accumulators, various assemblies of a solar water heater with vacuum tubes, the structure of a solar water heater, the composition and advantages of the operation of vacuum tubes;
- shows the skills to install a solar collector, depending on the solar resources and conditions on the territory of the university. the prospects for the development of a solar thermal device are given.

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