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TECHNOLOGY FOR GENERATING ARTIFICIAL WIND AND ITS APPLICATION IN ENERGY PRODUCTION

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Abstract

The diversity of forms of electrical energy use in virtually all areas of our society underscores the relevance of the concept of developing more powerful energy sources that cause minimal harm to the environment. Wind energy, which has undergone rapid development, has until recently been considered one of the most environmentally friendly ways to generate energy. However, as our knowledge of environmental issues has expanded, its numerous shortcomings have become apparent. The proposed technology not only allows artificial wind to be generated in any local area, but also uses turbine-type wind generators, which eliminate all the disadvantages of traditional wind generators. The article proposes a design for a wind power plant that implements this technology, considers issues related to its daily activity, and analyzes how its parameters depend on the seasons. A modification of the wind power plant is proposed for construction in foothill areas, where the highest power generation rates are achieved.

Key words: artificial wind generator, wind power plant, turbine-type wind generator, energy ecology.

Introduction

Growing public demand for the preservation of our planet's ecological purity is encouraging scientists to develop more powerful sources of renewable energy capable of replacing nuclear and thermal power plants, which cause the most damage to the environment. Not only do they produce high levels of harmful emissions, but each of them, with an efficiency of approximately 30-40%, releases the remaining energy from its production cycle into the atmosphere in the form of thermal energy, which is twice the amount of energy supplied to the homes of its actual consumers.

Hydropower is the cheapest and most environmentally friendly way to generate electricity. With capital investments in power plant construction amounting to only $1,400 per 1 kW of energy, it generates 14.7% of global energy consumption, according to the International Energy Agency's data for 2024. However, its further development does not seem possible, as all countries have already fully utilized their water resources since the construction of the first power plant in 1882 in the United States on the Fox River (740 W) and the next more powerful one (37 MW) built on Niagara Falls in 1895. From this perspective, global wind energy resources can be considered inexhaustible. Therefore, despite the rapid growth in the share of wind energy in global electricity consumption from 1.1% in 2001 to 8.1% in 2024, it seems appropriate to develop more technologically advanced methods of converting wind energy into electricity and to conduct a comparative analysis of their parameters with the traditional technologies currently in use.

Disadvantages of traditional energy production technologies

Coal-fired power plants cause the most damage to our planet's environment, emitting 900 g of various harmful substances into the atmosphere for every 1 kW*hour of energy produced, a large proportion of which is carbon dioxide, emissions of which amounted to 40 gigatons in 2023 alone. The emissions from coal-fired power plants also include toxic compounds of lead, thorium, uranium, and other heavy metals, which can accumulate in the human body. Coal-fired power generation ranks second after hydropower in terms of capital investment in power plant construction, at $2,000 per 1 kW of capacity. Therefore, it is regrettable to note that coal is currently the largest source of electricity, generating 34% of the world's energy [1], which is more than three times the share of nuclear power plants (10%), which emit only 28 g of harmful substances per 1 kW *hour of energy into the atmosphere. However, nuclear power plant reactors produce about 300 different radionuclides, 30 of which can enter the atmosphere, with half-lives ranging from several days to several years.

During its operation, a nuclear power plant does not directly emit carbon dioxide, however, the concept of a “carbon footprint” has been introduced for them, which includes the amount of carbon dioxide generated during uranium ore mining, uranium enrichment, and radioactive waste management, amounting to 88-146 g per 1 kW*hour of energy generated from this fuel [2]. The disadvantages of nuclear power plants include very high capital investments in their construction—$5,500 per 1 kW of capacity—and equally high costs for decommissioning. The Massachusetts Institute of Technology has calculated that the cost of decommissioning a nuclear power plant is 10-15% of the cost of its construction. However, experience shows that in some cases these costs can be many times higher. For example, in France, the cost of decommissioning the Brenilis nuclear power plant increased 20 times compared to the planned cost and amounted to €480 million. In the UK, 19 nuclear power plants are decommissioned each year, costing £3 billion in budget funds.

According to Climate News Network estimates, 48 of the 144 nuclear power plants operating in Europe should begin the decommissioning process as early as 2025. This is despite the fact that such advanced countries as Austria and Germany stopped building new nuclear power plants back in 2000. This was dictated not only by the noted shortcomings of nuclear power plants operating in normal mode, but also by the continuing threat of accidents with unpredictable consequences. On April 20, 1986, an explosion at the Chernobyl nuclear power plant released radioactive substances into the environment equivalent to 500 Hiroshima bombs. On March 11, 2011, despite strict compliance with operating rules, a 15-meter tsunami flooded the «Fukushima-1» nuclear power plant and caused three reactor core meltdowns. The process of gradually abandoning nuclear energy is influenced not so much by the high costs of construction and decommissioning, but primarily by the steady increase in its cost as our knowledge of environmental issues grows [3] and the requirements for the construction of nuclear safety systems and the process of storage and disposal of nuclear waste increase. At the same time, the cost of wind and solar energy is steadily decreasing as technology advances, and the share of solar energy production worldwide has doubled over the past three years, reaching 6.9% in 2024. One of the disadvantages of solar energy is its high capital investment—$4,000 per 1 kW of capacity, second only to nuclear energy. The efficiency of solar panels declines by about 1% per year, so the entire fleet of panels in solar power plants needs to be replaced every 25 years. According to the US National Renewable Energy Laboratory, recycling solar panels is not economically viable: recycling one panel costs $20-30, while only $2-4 worth of materials can be recovered for reuse. Therefore, only in some countries are up to 10% of panels recycled, while the majority are dumped in landfills, transferring toxic heavy metals such as cadmium, selenium, and lead there. According to estimates by the Foundation for Environmental Education (FEE), the amount of this waste will reach 160 million tons by 2050, which is four times the amount of waste from wind turbine blades.

The harm caused by the production of solar panels is also a major concern for scientists [4]. The process of obtaining silicon from silicon dioxide (silicon ore) is extremely energy-intensive, involving the preliminary processing of ore in special furnaces, which consume 40-60 MW*hour of energy per ton of silicon produced, which is supplied by coal-fired power plants to keep production costs low. In the process of producing this amount of energy, these power plants emit 200-400 tons of carbon dioxide into the atmosphere. Therefore, although solar panels do not emit harmful substances during their operation, the "carbon footprint" from their production is 170-250 g per 1 kW*hour of energy generated [5]. The production of solar panels is also characterized by toxic soil and water pollution. After being processed in a furnace, silicon is extracted from ore through a chemical reaction with sulfuric acid, resulting in 3-4 tons of silicon tetrachloride being released for every ton of silicon produced. In most countries, this is simply dumped into rivers, as its processing requires high costs and special equipment.

Disadvantages of traditional wind generators

Capital investments in the construction of wind power plants (Fig. 1) are almost two times lower than those for solar power plants and amount to $2,200 per 1 kW of capacity according to 2024 data. However, compared to solar panels, their installation and further operation are extremely complicated.

Fig. 1. Wind turbine design and their location on the site.

Due to the absence of harmful emissions into the atmosphere, wind energy has long been considered comparable to hydropower in terms of environmental friendliness. However, as various aspects of its interaction with the environment have been studied in greater detail, some very significant drawbacks have become apparent:

- Wind power plants generate infrasound with a frequency of about 20 Hz, which is very harmful to humans and cannot be combated by technical means, since it arises when the wind flow comes into contact with the blades and has a high penetrating ability, unlike sound vibrations.
- Infrasound scares away snakes, rodents, small predators, and birds, which leads to the proliferation of pests and makes the fields under wind turbines unsuitable for agriculture and animal husbandry.
- Wind turbine blades kill birds and bats. American scientists from the animal protection service have determined that wind turbines killed 440,000 birds in one year, and coastal wind turbines killed 200 bats in just six weeks.
- After the blades reach the end of their service life, the composite materials they contain prevent them from being used as secondary raw materials. Therefore, landfilling is the only way to dispose of them, which a number of European countries have already banned on their territory. Nevertheless, this problem adds to the global problem of plastic waste disposal, and by 2050, 40 million tons of spent blades will need to be disposed of somewhere [6].
- Moving wind farms to the sea is no less destructive to nature. In the absence of visible changes on the surface, the entire spectrum of vibrations generated by the turbine supports is transmitted to their base, dispersing sea creatures and traveling through the aquatic environment over considerable distances. Energy specialists and environmentalists do not draw any conclusions from the fact that only higher marine mammals, which have a system of echolocation and sound communication between individuals, are washed ashore «for unexplained reasons».

It is very interesting to compare the characteristics of wind and hydroelectric power plants. In the latter, a dam on the river acts as a reservoir, directing the entire flow of river water into the turbines, transferring all its energy to them. This is not the case with wind generators—direct measurements on their design drawing (Fig. 1) show that only 5% of the wind passing through its overall size (red line) comes into contact with the wind generator blades. Taking into account international standards requiring a safe mutual arrangement of wind turbines at a distance of at least 5 diameters of the wind wheel, it turns out that a group of wind turbines converts only 1% of the energy of the wind blowing on them into electricity. In this regard, it should also be noted that before installing wind turbines in a particular area, each country conducts measurements of the wind speed and its seasonal stability necessary for the operation of wind turbines over a period of 2-3 years. Of course, these studies do not always yield positive results.

Artificial wind generation technology.

The noted shortcomings of traditional wind turbines are completely eliminated in the design of the wind power plant [7], which uses “artificial wind” technology. This technology allows an artificial difference in atmospheric pressure to be created on both sides of a wall facing south at any local site, and the wind generated by the pressure difference to be directed into turbine-type wind generators (Fig. 2) located at the base of the wall. This technology is based on a very interesting physical phenomenon that manifests itself in hurricane-force winds at the base of tall buildings, caused by the large pressure difference between the facade of the building, which is strongly heated by the sun, and the low temperature in the shaded area on its north side [8]. Such winds, artificially generated in urban conditions, blow along the streets adjacent to the building, knocking pedestrians and cyclists off their feet [9,10]. The technology for reducing the intensity of these winds [11,12], which analyzes the process of their formation around skyscrapers with south-facing facades, proposes installing pipes running from north to south on the technical floors of such buildings, which will provide the wind with a shortened corridor through the building (Fig. 3) and reduce its speed on the streets. The pipes enter the building from the area of highest atmospheric pressure at the very base of the northern wall of the skyscraper and exit from the south at the level of the second floor so as not to interfere with pedestrians and traffic. At the same time, the air flow in the pipes is quite powerful—the wind at the pipe outlets has a speed of 20-30 m/s and is ejected up to a distance of 40 m [8].

The installation of generators in pipes is an obvious consequence of this technology, bringing it into the field of energy. To preliminarily assess the potential of this method for energy generation, the results of computer modeling of the process of solar heating of the aluminum-clad Bridgewater Place skyscraper on June 22 (Fig. 4) and December 22 [8].

The calculated values of the temperature difference between the building facade and its shaded area, which forms wind in the pipes, reach 50^0C in summer and 60^0C in winter, which allows the classic theory of a «thermodynamic machine» to be used for the case of a minimum temperature difference. The efficiency in this case will be $Q = 50^0K / 300^0K = 1/6$, where 300^0K is the average temperature of the system. The initial energy of the entire system is determined based on the energy of solar radiation falling on 1 square meter of surface area - 0.6 kW. For the Bridgewater Place skyscraper, with a height of 112 m and a width of

80 m, the total energy is 5,376 kW, which, taking into account the efficiency Q = 1/6, gives a resulting power E = 896 kW.

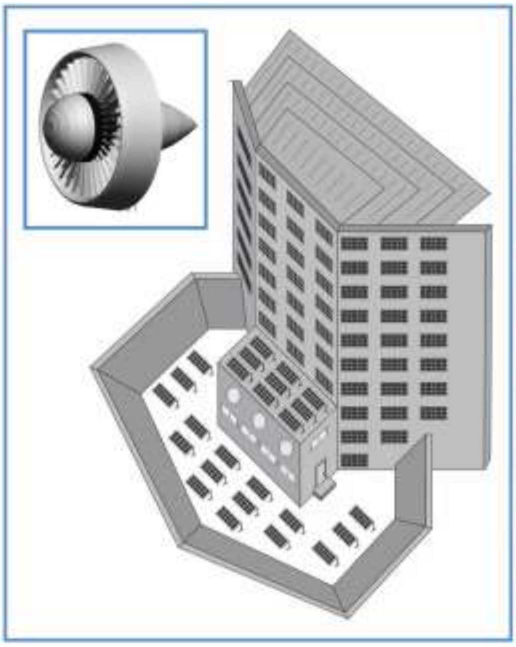


Fig. 2. Wind farm and turbine-type wind generator.

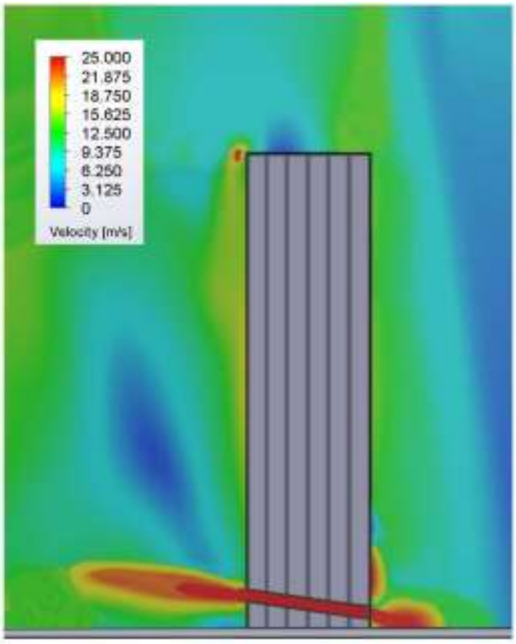


Fig. 3. Technology for reducing wind speed at the base of a skyscraper.

A more accurate assessment, taking into account the physical aspect of the phenomenon, is provided by examining a computer model of the upward air flow on the facade of the Bridgewater Place skyscraper (Fig. 5), formed when it was heated to 73^0C on June 22 (Fig. 4). This air flow moves at a speed of 11.1 m/s and carries a volume of air of 10,983.7 m^3/s. As this volume moves upward, the same volume of air is drawn in through the pipes, for which the mass can be calculated taking into account the air density of 1.225 kg/m^3 and the kinetic energy E = 833 kW. These two practically identical estimates show that an aluminum-clad surface area of approximately 10,000 square meters can generate enough energy to power 600 apartments (according to European standards - 1.4 kW per apartment) [13,14].

The design of the power plant (Fig. 2) is intended for industrial implementation of the noted physical phenomenon and amplification of factors influencing the process of artificial wind formation through the use of additional technical means.

To this end, the entire territory of the power plant is divided into northern and southern sections by a wall, the surface of which, together with the adjacent southern section, is covered with heat-absorbing shields to form the strongest possible upward flow when heated by the sun. Special materials such as technically pure aluminum - AD1(1050) or stainless steel - AISI304, which have a higher thermal conductivity and solar radiation absorption coefficient than the decorative aluminum sheet used to clad the Bridgewater Place skyscraper, which heats up to 73^0C on June 22. The maximum heating temperature can be achieved with the help of special selective paint used in solar collectors - Thurmalox 250 and selective coating based on titanium oxynitrate - Tinox, which significantly reduce the surface heat radiation coefficient and create a “heat trap” effect in the collector design. Solar panels, which heat up to only 60^0C in the sun, can also be used as heat-absorbing shields, but in this case, the power plant will operate in hybrid mode and make full use of all its surfaces.

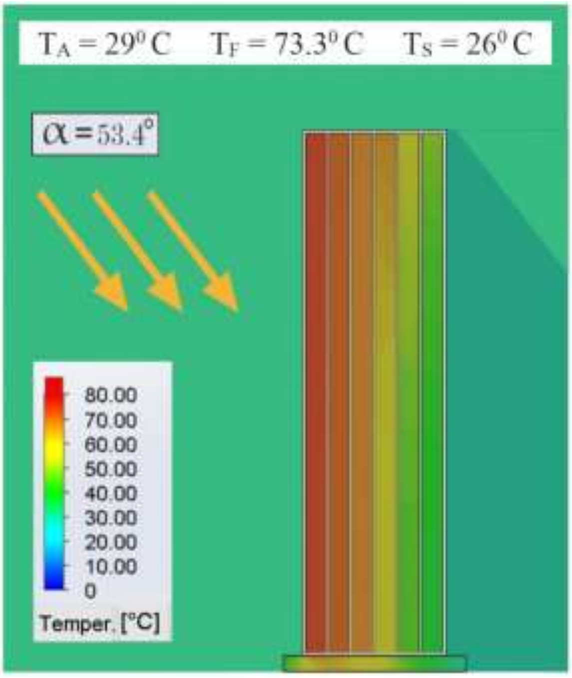


Fig. 4. Simulation of solar heating of the Bridgewater Place skyscraper on June 22.

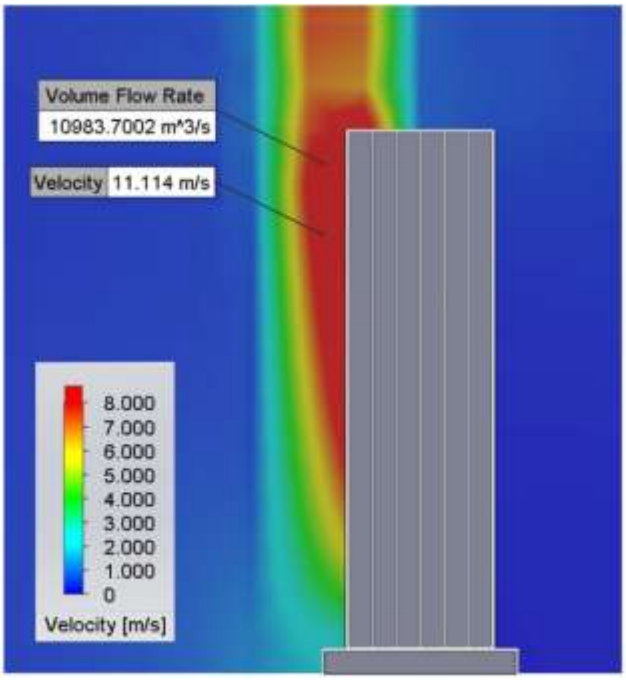


Fig. 5. Computer model of the updraft on the facade of the Bridgewater Place skyscraper.

A very important design element is the fence around the southern section of the power plant, which prevents ambient air from being drawn into the low-pressure area at the base of the wall formed by the upward flow. In this case, all the air compensating for this pressure drop will be drawn in through the pipes on the northern side of the power plant. This will be facilitated by the location of the fence above the level of the pipe outlets, which, for the safety of personnel, are located at the level of the second floor of the control building. The walls of the fence should be tilted outward from the station territory at an acute angle so as not to shade the sun from the heating shields. Special measures have also been taken in the design of the power plant to maintain cold night temperatures in its northern section for as long as possible. To achieve this, side barriers have been built on both sides of the central wall to prevent sunlight from entering this area even at sunrise and sunset, and the common roof has a stepped structure that allows snow to be thrown off it onto the ground and ensures long-term cooling. The roof supports must be made of massive reinforced concrete structures and arranged in a checkerboard pattern to ensure sufficient contact with the air drawn into the area for maximum cooling.

For computer modeling of the wind power plant operation process, its design (Fig. 2) is represented by the following dimensions: vertical wall surface area - 100 x 100 m, northern and southern areas - 100 x 100 m. The computer model of this structure (Fig. 6) is represented by hot (red) and cold (blue) areas separated by a wall with 10 holes, each 9.8 m in diameter. The process of heating this structure by the sun is calculated for the coordinates of Marseille (southern tip of Europe, France) at two extreme points of solar activity - June 22 and December 22, provided that the entire surface of the vertical wall and the southern horizontal section of the power plant are clad with 3 mm metal with a thermal conductivity coefficient of 150 W/m*K (with a maximum of 230 W/m*K for pure aluminum), a solar energy absorption coefficient of 0.96 (with a maximum of 0.99 for Black Chrome) and a thermal radiation coefficient of 0.52 (with a minimum of 0.04 for Tinox coating). The simulation was performed using the "Flow Simulation 2024 SP2.0.Build: 6320" version of the SOLIDWORKS computer program, taking into account the ambient air temperature T_A by hour and season of the year in accordance with data from the French National Meteorological Service (MFI) [15].

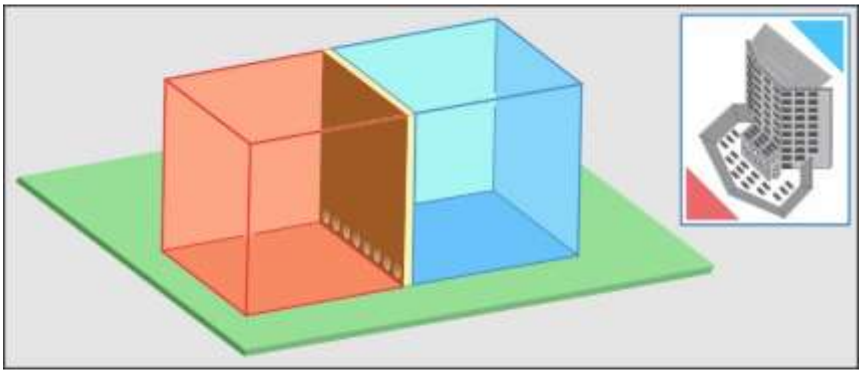


Fig. 6. Computer model of a wind power plant.

The results of computer modeling show that the vertical and horizontal surfaces of the model in Fig. 6 are heated to the maximum on June 22 when the sun reaches its zenith and form thermal zones (Fig. 7) with temperatures in the center T_V = 108.6 ^{0}C and T_H = 135.2 ^{0}C, respectively. Each of the marked thermal zones forms an upward air flow (Fig. 8), which, when moving upward, draws in volumes of air P_V and P_H (Tab.1) through the pipes, generating power E_V and E_H in the pipes. The analysis does not take into account the factors of additional heating of the marked surfaces due to their mutual influence, however, the result of simply summing the E_0 calculated values of the power they generate shows that equipping a vertical wall the size of the Bridgewater Place skyscraper with special technical means that enhance the process of artificial wind formation allows the amount of energy generated to be increased from 0.8 MW to 4-7 MW. Such a power plant can be built in any chosen location, regardless of its wind rose, in close proximity to any populated area and provide electricity to 4,000 apartments. Taking into account the global solar irradiance constant (1361 W/m²), the power plant's efficiency under the optimal conditions described above will be 25.7%.

The data in Tab.1 show an interesting pattern: in winter, when the vertical wall is relatively cool, it generates more power than in summer due to the large difference between its temperature and the temperature of the northern part of the power plant. This pattern also applies to the heating of the horizontal surface of the power plant, increasing the level of energy generated in winter, but this is not reflected in its excess over the level of energy in summer due to the very low heating temperature of the horizontal surface in winter, caused by the low angle of the sun above the horizon (December 22, Marseille, zenith - 23.27^0) and the position of its rays practically tangential to the surface. It should be noted that such a low position of the sun in winter is preferable for heating a vertical wall—the sun's rays fall on it almost perpendicularly, so even at low ambient temperatures, it heats up only 25% less than in summer and generates 25**%** more energy due to the temperature difference mentioned above. From this perspective, it can be stated that the operating cycles of vertical and horizontal surfaces complement each other, which allows for smoothing out seasonal fluctuations in the total generated power E_0.

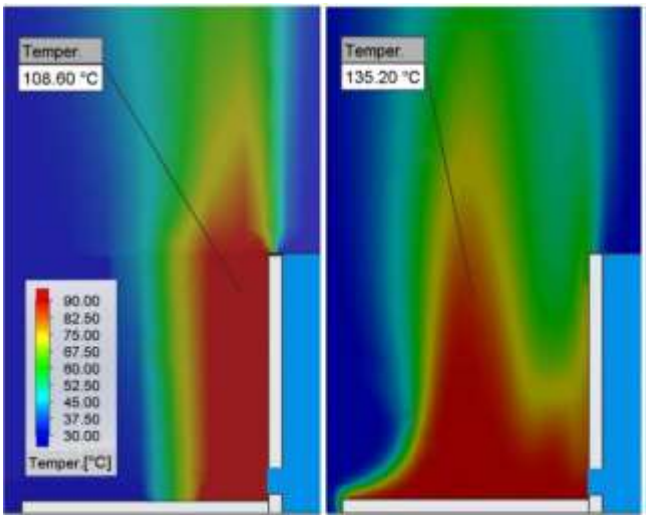


Fig. 7. Thermal zones of the vertical and horizontal surfaces of a wind power plant.

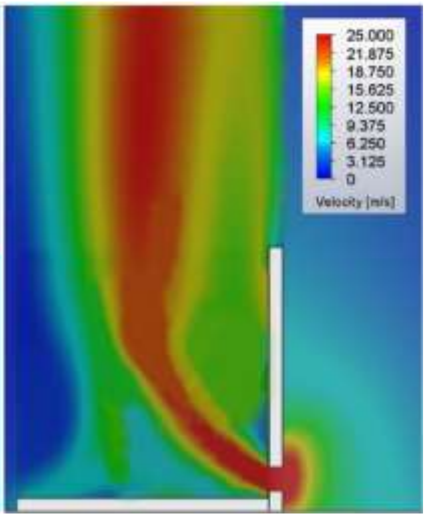


Fig. 8. Upward flow of a wind power plant.

Taбле 1

Wind farm parameters on June 22 and December 22 (sun at its zenith)

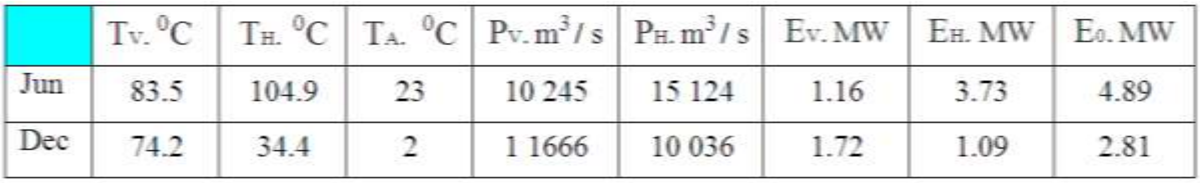
	T_{V}. ^{0}C	T_{H}. ^{0}C	T_{A}. ^{0}C	P_{V}. m^3/s	P_{H}. m^3/s	E_{V}. MW	E_{H}. MW	E_{0}. MW
Jun	108.6	135.2	32	12 058	16 878	1.89	5.18	7.07
Dec	96.3	53.1	10	12 983	11 924	2.36	1.83	4.19

Operating exclusively within the framework of solar energy conversion, wind power plants are characterized by a longer daily activity cycle than solar panels, due to the presence of elements with thermal inertia in their design, which maintain the temperature regime for some time after sunset in both the cold and heated areas of the power plant. The thermal inertia of the entire structure can be significantly increased through the use of special technologies for storing solar heat and accumulating cold during the night, using liquid elements of solar collectors that can be built into the walls and foundations of both areas of the power plant. The use of these technologies can ensure continuous energy generation, and the analysis of its daily fluctuations should be combined with an assessment of the costs of creating a thermal inertia system. Such an analysis should also be based on a compromise choice of the volumes of use of well-known energy conversion and storage technologies, which are an integral part of solar power plants and traditional wind turbines.

To assess the daily activity of a wind power plant without taking thermal inertia into account, computer modeling of its operation was performed at 9 a.m. on June 22 and December 22. Calculations of the sun's movement along the ecliptic [8] show that in both summer and winter, by 9 a.m. it has already risen more than halfway to its daily maximum and provides an average of up to 70**%** of the maximum energy produced by vertical and horizontal surfaces in each season (Tab.2).

Tabле 2

Wind farm parameters on June 22 and December 22 (9:00 a.m.).



	$T_{V.}$ ^{0}C	$T_{H.}$ ^{0}C	$T_{A.}$ ^{0}C	$P_{V.}$ m^3/s	$P_{H.}$ m^3/s	$E_{V.}$ MW	$E_{H.}$ MW	$E_{0.}$ MW
Jun	83.5	104.9	23	10 245	15 124	1.16	3.73	4.89
Dec	74.2	34.4	2	1 1666	10 036	1.72	1.09	2.81

This allows us to conclude that during daylight hours, fluctuations in the level of energy generated do not exceed 30**%** and can be stabilized at 80-85**%** of the maximum using energy storage and stabilization technology. The power plant's operation was simulated only from dawn to zenith because, in terms of solar radiation intensity, all processes are mirrored until sunset, and a special methodology needs to be developed to study the impact of thermal inertia processes occurring after the sun passes the zenith on the power plant's parameters [8].

For the construction of wind power plants generating higher capacities, heat-absorbing shields with higher “thermal” characteristics than those used in the calculations can be used. For comparison, it should be noted that if the above-mentioned higher characteristics of heat-absorbing material are used in the simulation, which showed a result of heating the horizontal surface to 135.2 ^{0}C, the surface temperature will increase to 198.4 ^{0}C. A further increase in power can only be achieved by increasing the surfaces that generate upward flows in the power plant. It should be noted that, according to the results of computer modeling, the upward flow from the horizontal surface contributes the most to the total energy. Consequently, increasing the size of this surface is preferable when constructing power plants.

Operational advantages of wind power plants

The high energy performance of wind power plants is complemented by a number of operational advantages due to the concentration of their entire output power in a narrow section of pipes, which makes it possible to install turbine-type wind generators in them. This primarily leads to a sharp reduction in the size of the wind wheel compared to traditional wind turbines, which must have a diameter of 35 m to generate 1 MW of power, while the world's most powerful wind turbine, the Enercon E-126, manufactured in Germany since 2012, has a diameter of 126 m and a total weight of 6,000 tons. With a capacity of 7.58 MW, comparable to that of a wind power plant (Tab.1), it is designed to supply power to 5,000 apartments (1.5 kW each) [14], but has not found application due to its high price of $14 million.

The use of turbine-type wind generators in power plants makes energy generation very technologically advanced—generator maintenance is carried out directly in the power plant building, rather than at a height of 100 meters or more. The all-metal construction of the turbine generator is easy to repair and can be recycled without loss at the end of its service life. Operating in the high wind speed range, turbine generators are characterized by high speeds, which eliminates the formation of infrasound harmful to humans and converts vibrations into the sound range with noise levels of 30-40 decibels, with an acceptable level of 45 decibels for residential and office premises and 55 decibels for factory premises. This allows wind farms to be built near residential buildings and ensures the safety of maintenance personnel. The design of these generators allows for external sound insulation and the installation of protective grilles, making them safe for humans and animals.

Turbines with a diameter of up to 6 m are manufactured at some European universities for installation on the roofs of their buildings and are estimated to cost $2,000. At the same time, steam turbines were characterized by a more complex design when they were first used in 1899 at a coal-fired power plant in Elberfeld (Germany), where a 15-stage steam expansion method was used in a turbine with a diameter of 2 m. Currently, turbines with a diameter of up to 4 m are being produced at a cost of $400 million per 1 GW of capacity. A similar calculation based on Tab.1 shows that wind turbines cost $5.5 million per 1 GW of capacity, which is incomparably lower.

This comparison allows us to estimate the capital investment required to build a wind power plant, assuming that a nuclear power plant of the same capacity has the same low-cost turbine and the same cost of housings, which together correspond to the total cost of the wind power plant shown in Fig. 2 and are denoted by A. In this case, the cost of the reactor, the first and second steam generation circuits, the condenser, and the cooling towers is added to this cost for the nuclear power plant, which is denoted by 2A, as well as the cost of the radiation protection complex, which accounts for 40% of the total cost of the nuclear power plant. Therefore, its total cost can be represented by the equation $B = A + 2A + 0.4B$, which is converted to the form $B = 5A$. Thus, capital investments in the construction of a wind power plant amount to $1,100 per 1 kW of capacity, which is lower than the cost of constructing hydroelectric power plants with the same indicators of absolute environmental safety.

Wind power plant in the foothills

The capacity of the wind power plant shown in Fig. 2 can be significantly increased if the cold air from the northern part of the plant is replaced with air from the mountain range [16], which is drawn from the area of highest atmospheric pressure at its base through pipes laid under the foothills and fed directly to the south-facing wall of the power plant with turbines located in it (Fig. 9). For the construction of such a power plant, it is advisable to choose a location that includes foothills (Fig. 10), which serve as a barrier to the wind blowing from the mountains into the valley and form the above-mentioned area of high pressure at the base of the mountain range.

Pipes leading into this area provide cold air with a shortened corridor into the sun-warmed valley and the power plant area, which is heated by additional technical means. The location of the pipes at a considerable distance from each other helps to ensure that the areas of air intake do not overlap and weaken each other. The wind formed in the pipes will help reduce pressure at the base of the mountain range, causing new flows of cold air blowing from the mountains to descend there, which will be completely drawn into the pipes and fed to the wind turbines of the power plant. The above description of how a foothill wind power plant works shows that it is significantly more productive than traditional wind turbines installed on foothill elevations (Fig. 1), whose blades capture only 1**%** of the wind blowing from the mountains.

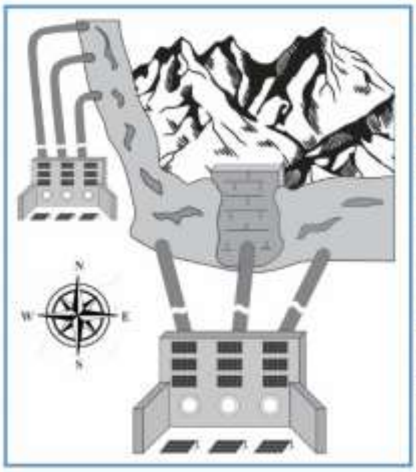


Fig. 9. Foothill wind power plant.

Fig. 10. Foothills in the Alps.

To build such a power plant, it is preferable to locate it south of the mountain range in accordance with the requirement that the central wall of the power plant face south for maximum heating by the sun. However, the power plant can also be built on any section of the mountain range (Fig. 9), in which case the pipes can be given a smooth bend to maintain the southward orientation of the entire power plant structure. The features of the landscape may allow the pipes to be led into the valley through natural passages between the foothills, which, after the pipes have been laid, are built up with a wall (Fig. 9) that serves as the same barrier to mountain air as the foothills. This technique allows mountainous terrain without foothills to be used for the construction of a power plant. In this case, the dimensions of the wall must be significantly expanded so that it can function as a dam in the above example with a hydroelectric power plant. For a preliminary assessment of the technical characteristics of the proposed energy generation method, it is interesting to compare it with the “Atmospheric Power Plant” [17], developed by the American company "Cold Energy" in 2004.The company's scientists calculated that between geographical points 300 km apart, an atmospheric pressure difference of 0.03 atmospheres (22.8 mm Hg) is formed. If three pipes with a diameter of 2.5 m are laid between these points, a supersonic wind will form in them, which will allow generating up to 1 GW of power at a cost of 0.1-1 cent per 1 kW* hour. The project was not implemented due to the long length of the pipes passing through several states [18]. The proposed power plant allows the high technical characteristics of the noted project to be realized by using the atmospheric pressure difference between such diametrically opposed climatic zones as a snow-covered mountain range and a residential area in a sun-warmed valley (Fig. 10), which are located in close proximity to each other and separated by foothills. With temperatures in the Alps ranging from -10 to -15 ^{0}C and daytime temperatures “in the sun” ranging from 33 to 38 ^{0}C, according to data from the MFI in Marseille, located at the southwestern tip of the Alps, there is a temperature difference of approximately 50 ^{0}C and an atmospheric pressure difference of 14 mm Hg between them (0.28 mm Hg for every 1 ^{0}C). This is even without taking into account the humidity of the mountain air and special measures for additional heating of the southern section of the power plant (Fig. 9). At the same time, a wind flow with a speed of 174.6 m/s is formed in a single pipe with a diameter of 10 m and a length of 100 m, which generates 250.1 MW of power [19]. When the diameter of the pipe is reduced to 6 m for the installation of the above-mentioned 6-meter turbine-type wind turbines manufactured in European universities, the power generation decreases to 41.9 MW, which is nevertheless sufficient to supply electricity to a city with a population of approximately 120,000 people. The calculations assume that, to reduce the internal resistance of the pipes, special «epoxy smooth coatings» – such as the widely used brands «Amercoat» and «Scuthkote», which have a friction coefficient of 0.01– have been applied, as is common practice in gas pipeline technology.

The capacity of such a power plant can be increased by heating its territory with heat-absorbing shields, which, according to Tab.1 and Tab.2, will increase the temperature difference by an average of 50 ^{0}C even in winter, since the temperature in the mountains also drops at this time. When a temperature difference of 100 ^{0}C (28 mm Hg) is reached at the ends of a 6-meter pipe 100 m long, the wind speed in it will be 191.2 m/s and the power generation will reach 118.5 MW. Under the same conditions, a wind speed of 246.9 m/s will be generated in a 10-meter pipe, and the power will be 708.9 MW. The above assessment of the power of some options for implementing the principle of a foothill wind power plant highlights the prospects for the development of this method of energy generation and provides an opportunity to combine the efforts of many scientists, both from the energy sector and from related fields of science, to create a unified theory for the construction of such power plants and to develop methods for testing their parameters. In particular, it follows from the above that such power plants can contain either one pipe or several pipes connected to a common control point (Fig. 9). In the latter case, only the central pipe operates optimally, while the length of the side pipes increases significantly, leading to energy losses and requiring a compromise solution. For example, if the side pipes are directed at an angle of 45^0 to the central pipe, they become 1.4 times longer, which leads to a 20**%** power loss in each of them. In this case, it may be more expedient to build a separate control point for each pipe, located in a straight line towards the mountain range. In this case, the object of further research will be the optimal choice of the distance between power plants, which excludes mutual overlap of the areas of air flows drawn into their pipes. To evaluate this factor, calculations were performed on a computer model of a foothill wind power plant (Fig. 11), which includes the heated section of the power plant model shown in Fig. 6, connected by pipes to a segment of the mountain range, the walls of which, according to the program conditions, are closed to external air access from all sides except the top.

The results of calculations performed with a gradual increase in the size of the mountain massif segment show that the increasing power generated slows down the growth dynamics many times over at a level of about 1.5 GW with a mountain massif segment size of 3x3x3 km. This leads to the conclusion that the cold air resource contained in this segment allows the specified power to be generated without drawing in additional air masses from areas outside the segment, where neighboring power plants can operate at full capacity. The above calculations also allow us to make a first approximation of the cold air resources of the Alps - with a ridge length of 1,200 km and a width of 260 km, their area is 312,000 square kilometers, which accommodates 34,667 segments used in the calculations, each with a resource of 1.5 GW. Consequently, the energy resource of cold air in the Alps is 52,000 GW. This assessment does not take into account a number of natural factors that require narrow specialization. Due to the fact that the intake of heavy cold air into pipes from the upper layers of the atmosphere occurs not only in computer models but also in real nature, it is necessary to take into account the "vertical temperature gradient" (VTG), according to which the air temperature decreases by 5-6 ^{0}C for every 1,000 m of elevation.

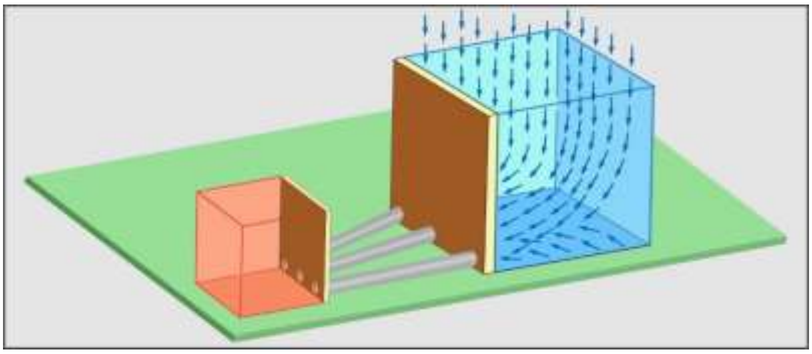


Fig. 11. Computer model of a foothill wind power plant and air movement in a mountain range segment

Therefore, in calculations with a temperature at the base of the mountain range equal to -10 ^{0}C, a correction must be made for the colder air coming from both the mountain peaks of the Alps with an average height of 2.5 km and the nearby heights of Mont Blanc (4,810 m) - the highest peak in the Alps, located on the border between France and Italy.

Conclusion

The proposed artificial wind generation technology provides an opportunity to develop a new generation of wind power plants, whose performance does not depend on the "wind rose" of the area and is determined only by the size and thermal characteristics of the sun-heated power plant structures. A south-facing vertical wall measuring 100x100 m and the adjacent area of the same size at the extreme points of solar activity on June 22 and December 22 generates 4-7 MW of power at noon with daily activity fluctuations of 30%, calculated for 9:00 a.m. The use of well-known technologies makes it possible to increase the thermal inertia of the power plant's structure and ensure round-the-clock energy generation, the parameters of which require the development of a special methodology for diagnosis. The construction of a wind power plant in the foothills allows the limited volume of air in its shadow area to be replaced by a significantly larger volume of colder air from the mountain range, which makes it possible to generate up to 1.5 GW of power and place power plants 3 km apart.

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ԱՐՀԵՍՏԱԿԱՆ ՔԱՄՈՒ ԳԵՆԵՐԱՑՄԱՆ ՏԵԽՆՈԼՈԳԻԱ ԵՎ ՆՐԱ ԿԻՐԱՌՈՒՄԸ ԷՆԵՐԳԵՏԻԿԱՅՈՒՄ

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Երևանի կապի միջոցների ԳՀԻ

Էլեկտրական էներգիայի օգտագործման եղանակների բազմազանությունը ընդգծում է առավել հզոր էներգիայի աղբյուրների նախագծման կարևորությունը, որոնք բնութագրվում են նվազագույն ազդեցությամբ շրջակա միջավայրի վրա: Արագ զարգացում ստացած հողմային էներգետիկան մինչև վերջին տարիները համարվում էր առավել էկոլոգիապես մաքուր տեխնոլոգիաներից մեկը: Սակայն շրջակա միջավայրի խնդիրների մասին մեր գիտելիքների ընդլայնումը ի հայտ բերեց այդ տեխնոլոգիայի բազմաթիվ թերությունները: Առաջարկվող տեխնոլոգիան ոչ միայն թույլ է տալիս գեներացնել արհեստական քամին ցանկացած տարածքում, այլ և օգտագործում է իր աշխատանքային սկզբունքում տուրբինային տիպի հողմագեներատորներ, որոնք թույլ են տալիս հաղթահարել ավանդական հողմագեներատորների բոլոր թերությունները: Հոդվածում առաջարկված է հողմային էլեկտրական, որը իրագործում է նշված տեխնոլոգիան, դիտարկված է նրա չափանիշների կայունության գործոնները օրվա և տարվա կտրվածքով: Հողմային էլեկտրակայանի նախալեռնային տարածքում կառուցման տարբերակը թույլ կտա գեներացնել առավել բարձր հզորություն:

Բանալի բառեր ՝ արհեստական քամու գեներատոր, հողմային էլեկտրակայան, տուրբինային տիպի հողմագեներատոր:

ТЕХНОЛОГИЯ ГЕНЕРАЦИИ ИСКУССТВЕННОГО ВЕТРА И ЕЁ ПРИМЕНЕНИЕ В ЭНЕРГЕТИКЕ

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Многообразие форм использования электрической энергии практически во всех сферах жизнедеятельности нашего общества подчёркивает актуальность концепции разработки более мощных источников энергии, характеризующихся минимальным вредом для окружающей среды. Получившая бурное развитие ветровая энергетика до последнего времени считалась одной из наиболее экологичных способов генерации энергии. Однако, расширение наших знаний о проблемах экологии выявило её многочисленные недостатки. Предложенная технология не только позволяет генерировать искусственный ветер на произвольно взятом локальном участке, но и использует в своей основе ветрогенераторы турбинного типа, устраняющие все недостатки традиционных ветрогенераторов. В статье предложена конструкция ветровой электростанции, реализующей отмеченную технологию, рассмотрены вопросы её суточной активности, проведён анализ зависимости её параметров от сезонов года. Предложена модификация ветровой электростанции для случая строительства её в предгорной местности, при которой достигаются наибольшие показатели генерируемой мощности.

Ключевые слова: генератор искусственного ветра, ветровая электростанция, ветрогенератор турбинного типа.

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