Chornobyl: a History of the Past or a Demonstration. How Science Can Solve the Problems of the Future?!

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Abstract. The possibilities of a well–known historical event as a starting point for teaching various scientific and technical aspects are shown. In particular, it is indicated how, as an example of the Chornobyl disaster, it is possible to elucidate in detail the principles of the work of the nuclear power engineering and the scientific basis of the processes that took place during and after the accident (based on sections of the school course of physics covering nuclear physics). It is also indicated for scientific discoveries and implementation, as well as engineering and technical solutions that were used during the elimination of the consequences of the accident. Thus, one man–made disaster allows us to disassemble this problem from the history of science and technology, physics, chemistry and ecology. Thus, this approach allows us to introduce the aspects of multidisciplinarity into learning, and to point out the interconnections of different types of sciences, which promotes a better understanding of the need for comprehensive development by students, and motivates the study of natural sciences [1–2].

Keywords. Chornobyl, Nuclear Physics, Power Engineering, History of Science, Chemistry, Ecology, Safety and Health, STEM Education.

1. Introduction

The example of the Chornobyl disaster will detail the principles of atomic energy and the scientific bases of the processes that occurred during and after the accident (physics section of the high school program on nuclear physics). Scientific discoveries and implementations, including the use of rapidly evolving alternative energy sources, as well as engineering and technical solutions used to eliminate the "aftermath" of the accident, will be analyzed and discussed (some issues of physics, chemistry and ecology will be considered). An important part of the project is labor protection and civil defense.

2. History

More than 30 years have passed, and the rainy day of the Chornobyl tragedy continues to excite people: both those whom he hooked with his black wing, and those who were later born far from the crippled land. This day did not pass without a trace – an unprecedented scale of tragedy struck the whole world.

The disaster of the Chornobyl Nuclear Power Plant (officially named the Chornobyl Nuclear Power Plant in honor of Vladimir Ilyich Lenin) that occurred at reactor No. 4 On April 26, 1986 is well known to everybody. It has been widely regarded as the worst accident in the history of nuclear power. It was the reason of large restricted area known as the Chornobyl Exclusion Zone appeared. Pripyat city and several other settlements were abandoned.

Due to the Decree of the Council of Ministers of the USSR of September 29, 1966 on the commissioning of energy capacities was planned to generate 11.9 million kW of power. After this Decree 8 million kW was planned to be generated by nuclear power plants. In the southern part of the USSR was planned to build a nuclear power station, which should provide electricity to the Central Energy Region – 27 regions of the Ukrainian SSR and Rostov Region with a total population about 53 million people.

It was taken into account that the most economically feasible radius of power supply is about 350–450 km. After the survey of 16 construction sites it were proposed two of them: near the village of Ladyzhiny, Vinnytsia region, and the village of Kopachi, Kiev region. The first name of the station was "Central Ukrainian NPP". The well–known Chornobyl Nuclear Power Plant in honor of Vladimir Ilyich Lenin appeared later.

On August 15, 1972, the first cubic meter of the main building concrete was laid. On September 26, 1977, the first Ukrainian nuclear power plant was run. The first power unit of the

Chornobyl nuclear power plant consisted of two RBMK–1000 reactors. The third and fourth power units with similar reactors were finished by the end of 1983. It was planned to run the fifth and sixth power units with the same reactors. But after the accident at the fourth power unit all constructions were stopped.

Directly in the Pripyat river valley to the south–east of the NPP site in order to provide cooling for turbine condensers and other heat exchangers of the first four power units, a 22 km² bulk pond cooler was built. It was planned to use cooling towers built near the fifth and sixth blocks under construction to ensure the cooling of heat exchangers. But the disaster happened earlier.

The accident at Unit 4 of the Chornobyl nuclear power plant occurred on April 26, 1986 during the safety systems tests. Two situations were simulated. The first was connected with complete loss of power supply to nuclear power plants, including main circulation pumps (MCP) and pumps for emergency reactor cooling system. The second test simulated the accident, in which considers the reactor circulation loop large diameter pipeline rupture.

The project provided that when the external power was turned off, the electricity generated by the turbo–generators due to run–out is supplied to start the pumps included in the emergency reactor cooling system, which would ensure guaranteed cooling of the reactor. It was the only attempt to do such experiment with RBMK – 1000 reactor from the time them were putted into operation.

Tests were scheduled to be held in the afternoon of April 25, 1986 on the basis of the reactor No. 4. The reactor thermal power at that time should be 700 MW, after which it was planned to shut down the reactor for scheduled repairs. Thus, the tests should have been carried out in a reduced power mode, which is characterized by an increased (relative to the nominal) flow rate of the coolant through the reactor, a slight heating of the coolants to the boiling point at the entrance to the core and minimum vapor content.

Tests began at 1:23:04. The four main circulation pumps began to work from the residual rotation of the turbogenerator. That leads to the decreasing of water flow and increasing steam content.

At 1:23: 43 a great increasing of power began. The three explosions sounded immediately. The reactor was destroyed, and huge volumes of radioactive substances came into the atmosphere. Reactor No. 4 was in fire.

The liquidation of the consequences began at the same night. Within a few hours after the destruction, firefighters and Chornobyl personnel were able to eliminate numerous fires, which prevented the threat of fire spreading to other power units. The risk has been huge because the 3rd power unit was located in the same building as the 4th.

On April 27, helicopters began to drop the protective materials into ruined building. After the two weeks of deadly work, the materials covered the central hall with a ball from 1 to 15 meters thick, isolating the reactor from the environment. At present, a new sarcophagus over the emergency 4th power unit has been commissioned. The new sarcophagus (called the “New Safe Confinement” (NSC)) was pushed into its design position in November 2016. The project was completed in May 2018.

3. Nuclear reactor physics

A nuclear power plant differs from a thermal one only in that the steam for turbines is heated by the energy of a nuclear reaction – the fission of uranium nuclei into two (occasionally three) large fragments. This process attracted the attention of physicists primarily because it can self–sustain, since it belongs to the chain.

Such a well–known chemical reaction as combustion goes on its own – it only needs fuel, an oxidizing agent and initial heat input. The “burning” of nuclear fuel is more difficult to ensure: for the nuclei to be divided, a personal match must be brought to each of them – a neutron. But nature provided this opportunity – during the decay of a nucleus several neutrons with an energy of about 2 MeV fly out. The chain reaction will continue if at least one of these neutrons, absorbed by the new nucleus, causes its fission and the appearance of the next generation neutrons. The ratio of the number of neutrons participating in a certain stage of a nuclear reaction to the number of neutrons of the previous generation at the same stage is called the multiplication coefficient K. This quantity completely determines the dynamics of the chain process:

at K = 1, the reaction proceeds at a constant speed, at K> 1 it accelerates, at K <1 goes out.

It would seem that since fission of one nucleus releases two or three (on average 2.3) neutrons, it does not cost anything to achieve an accelerated or at least stationary reaction. In fact, this is not easy at all, because for many reasons neutrons are eliminated from the game.

Having flown out of a split nucleus, a neutron can simply go beyond the limits of the reactor core. To reduce the likelihood of such a loss, the reactor is made large enough, and the core is surrounded by a reflector – a substance whose nuclei do not react with neutrons, but play the role of a barrier preventing their rapid leakage. If the neutron remains in the core, another danger lies in wait for it – entrapment of an impurity or structural material by the nucleus. Suppose this did not happen. Then, sooner or later, the particle will be absorbed by the nucleus of one of the uranium isotopes – 238U or 235U. When fast neutrons are absorbed in 238U, fission occurs only in 5 cases out of 100, and in the remaining 95, 239U is formed, and the neutron falls out of the multiplication chain. The nucleus of 235U will split in 85 cases out of 100, and only 15 neutrons will be uselessly spent on the formation of 236U. Natural ores contain 99.3% of 238U, while 235U contains only 0.7%, and in addition, the probability of capturing fast neutrons by the heavy isotope of uranium is much higher than light. Therefore, in pure natural uranium, a self–sustaining chain reaction does not occur.

If the neutron is not captured immediately by uranium, it wanders for a while inside the core, colliding with different nuclei and losing speed. In the end, its energy drops to 0.025 eV – the average energy of thermal motion and does not change anymore. Such slow, or thermal, neutrons are no longer able to cause 238U fission and, when absorbed by this isotope, will inevitably be lost for the reaction. But thermal neutrons can lead to fission of 235U nuclei — moreover, they are captured by a light isotope much more often than by a heavy one. But, slowing down in collisions, neutrons inevitably pass through the region of intermediate energies (1–10 eV), in which the probability of capture by 238U nuclei reaches a maximum. Therefore, if you do not take special measures, most fast neutrons simply do not have time to turn into thermal ones.

The solution was found in the use of a moderator – a substance, when moving in which neutrons are not captured, but quickly lose energy. Usually, uranium is placed in a moderator in small portions at a certain distance from each other. Fast neutrons arising from the fission of uranium in one of these parts, fly out of its limits in the moderator. Here the particles reduce the speed to thermal and then can travel for a long enough time until they again fall into uranium. Now they will almost certainly be absorbed by the nuclei of the light isotope and cause new fissions. The chain reaction goes further.

We touched on only a small part of the problems arising in the development of a nuclear reactor. Scientists and designers have to take into account many different factors, and most importantly, take into account that each of them can change over time, and take care that no changes can interfere with confident control of the reactor.

4. Power engineering

The traditional system of training high school students and then specialists in our country's technical colleges includes their theoretical and practical training in specific educational programs and curricula. It is mainly based on the transfer of scientific and technical knowledge to students and students and practically does not prepare them for those realities of life that the future specialist will encounter when it comes to production.

This problem becomes most urgent when it comes to preparing future specialists at the universities of the country for those industries that work with some risks to human life and the environment. These industries are, in the first place, first and foremost – large, sophisticated technical systems with many different objects and connections between them. These industries include, first of all, energy, metallurgy, the chemical industry, enterprises serving the military and space complex, and others. Confirmation of the extreme importance of this problem is the increasing number of technical (man–made) accidents and catastrophes in all countries of the world. Suffice it to name the accidents at the Three

Island nuclear power plants (USA), Chornobyl (Ukraine), Fukushima (Japan), the Sayano–Shushenskaya hydroelectric power station (Russia), the devastating accidents at the Baosian hydroelectric plants (China), the explosions and the fires at the plants, producing ammunition, serious transport accidents, offshore drilling rigs. They are all related not only to huge material losses, but also to human casualties, which are estimated by hundreds and thousands of people.

Numerous commissions investigating such at the technical sites, in the end, made the same conclusion: the cause of all these accidents, in the vast majority of cases, was the "human factor", i.e. the mistakes of people at different stages of the technical life facility or system, those people who designed these facilities, installed them, repaired the equipment, or engaged in their operation.

Therefore, the development of methods, techniques and skills that would help high school teachers and technical colleges, against the background of transferring scientific knowledge, to form in the students the professional skills they need for further practical activity, which would eliminate possible mistakes in design, montage and the operation of technical facilities and reduced the likelihood of accidents on them.

Based on the above, part of the teacher training program will be related to the study of the basics of building energy facilities and systems, environmental and energy security of the country and the principles of safe operation of Ukrainian energy facilities.

5. Chemistry

5.1. Immediately chemistry: three main problems of Chornobyl

After the 4th power unit explosion 3 main problems immediately appeared. In this case chemical engineers were needed to solve them. The first was to extinguish the reactor without using water, the second was dust suppression, because the main environmental pollution was caused by the emission of huge amounts of radioactive dust into the atmosphere. The third was the decontamination of buildings, roads and equipment. Unfortunately, there were no prepared action algorithms in these conditions.

In order to solve the first problem scientists decided to drop bags of sand, dolomite and lead (plumbum) from helicopters directly into the burning reactor. But this could only be done from a height of 200 m due to the difficult radiation situation (Figure 1).

Figure 1. A helicopter over sandbags with dolomite and parachutes with boric acid and liquid rubber [3]

The complexity of the work was explained by the necessity to hit the bags into the target. Lead was used in order melt to decrease the temperature of the hot radioactive fuel. At the same time a lead film is formed and reduces the radiation background. In addition, dry boric acid was also dumped into the burning reactor for efficient neutron absorption. Of course such activity caused dust formation which could not be allowed. At this time a chemical mini–workshop was immediately built to create special compositions that could quickly polymerize on the surface, forming insoluble films. Chemists on the spot improved these solutions, using combined polymers, phosphate compounds.

To solve the problem of dust suppression, liquid rubber was first used. It also was dumped directly on hot fuel. In addition to its main purpose, it reduced the temperature inside the burning reactor. After that vinyl–acrylic and bitumen–water emulsions were used (Figure 2).

Figure 2. Helicopter sprays dust suppression reagents [3]

The difference between them is that bitumen–water emulsions can collect dust particles into agglomerates and do not form a solid film like acrylic copolymers. These methods of dust suppression are the most effective and used all over the world. Such components were also used for the treatment of dirt roads on the territory of the Chornobyl nuclear power plant.

After the reactor explosion a radioactive cloud got into the air. The most active isotopes which are short–lived (the half–life is only eight days) were the most dangerous. First was iodine. The problem was in his high activity and ability to digest by living organisms and accumulated in the body which is the worst. Therefore, doctors spoke most of all about iodine, prohibited the greens from eating, checked milk very carefully and provided all workers with respirators to prevent thyroid glands from iodine penetration.

A month later radiochemists shifted their attention on plutonium when the biggest part of the radioactive iodine decayed. It is known as long–lived and toxic. Its accumulation even in small doses is quite dangerous for lungs.

Surfaces of buildings, equipment, and special vehicles were deactivated by different physicochemical methods from pollution of a mixture of fission products of uranium, radioactive isotopes and plutonium. All of them were based on washing surfaces with special solutions (Figure 3).

Figure 3. A helicopter sprays decontamination solutions [3]

Figure 4. Deactivation of the territory and vehicles [3]

These reagents either dissolve or combine radioactive isotopes into complex compounds that have to be removed in the end. For this purpose, chemists used surfactant solutions (gardinol, sulfonol, wetting agents OP–7, OP–10) and complexing agents. These substances significantly increase the deactivating ability of surfactant solutions, forming complex compounds with many metals (products of a nuclear explosion) that are quite soluble in water. When these compounds appear, the bonding forces of the radionuclides with the surface weaken. As a result, they can be easily removed from the contaminated surface. In order to maximizing efficiency of the decontamination process, solutions were prepared no late than a day before the use.

The treatment of equipment consisted of three stages: washing under high pressure, treatment with deactivation solutions and its subsequent washing off under high pressure (Figure 4).

5.2. Immediately chemistry: solution of radioecological problems

Even three decades after the Chornobyl disaster, in modern Ukraine, the development of effective sorbents for the extraction of radionuclides from aqueous solutions and soil is relevant because of the importance of radioecological problems caused by the accumulation and spread of radioactive contamination in the environment. The spread of radionuclides is facilitated by their high migration ability (especially strontium, cesium, uranium and technetium).

Solving these kinds of problems requires the combined efforts of scientists and developers working in various fields – environmentalists, chemical technologists, agrochemicals and biotechnologists.

Of particular interest in this regard are sorbents of natural origin, modified by artificial chemicals that combine sorption efficiency with harmlessness (and preferably – with benefit) to the environment, in addition, their use should have an economic effect.

All these requirements are fully met by humic and humic acids extracted from peat and lignite of Ukrainian deposits and sorbents made on their basis. These bioorganic substances exhibit high sorption capacity against radionuclides, heavy metals and other ecotoxicants, irreversibly linking the latter to chemical complexes. This property is especially valuable and relevant in conditions of high technogenic load, when in the form of dust and ash fall harmful compounds during the work of large industrial enterprises, as well as the level of radiation pollution. The introduction of humic preparations promotes the formation of insoluble sedentary complexes, which are derived from the circulation of substances in the soil. Thus, the products produced on such soils are much more environmentally friendly [4–5].

Due to carboxyl, hydroxyl, carbonyl groups and aromatic fragments humic acids enter into ionic, donor–acceptor and hydrophobic interactions, i.e. humic substances are able to bind different classes of ecotoxicants, which, together with their ecological properties, are natural, effective and natural which fully comply with the principles of green chemistry [6–7].

The heterogeneity of the structure of carboxylic acids on the one hand, gives an extremely wide range of properties, and on the other – nonspecificity of action. This can significantly complicate the process, so the task of creating humic substances with a more directional action does not lose relevance.

Modifications should be made to enhance the reducing properties (to neutralize oxidized actinides, such as plutonium). Phenol–formaldehyde condensation of hydroquinone and humic substances makes it possible to create a fairly environmentally friendly and effective reducing agent.

The sorption capacity can be increased by tying the gum to the mineral matrix. Given that the major constituent of natural minerals is silica, the most convenient way is to form a Si–O–Si bond between the humic substance and the mineral matrix. Then it is possible to obtain a powder with surface–active groups, which, upon dissolution in the reservoir, will adhere to the mineral surface.

By changing the degree of modification of humic substances, you can control the properties that will have a humic film, reaching the maximum degree of extraction of radionuclides.

Thus, on the example of sorption purification from soil radionuclides and natural reservoirs contaminated as a result of the Chornobyl disaster, as well as the reclamation of the affected territories, students of different specialties can be trained in solving technical and environmental problems at the intersection of sciences.

6. Ecology

Despite the fact that the Chornobyl nuclear power plant is located in Ukraine, Belarus suffered the most after the accident, about 60% of the emissions fell on its territory, and some of the radioactive dust settled on the lands of European countries (Sweden, Finland and Austria).

As a result of the accident, radioactive fallout contaminated more than 200 thousand square kilometers of Europe. Over 1 million people turned out to be in dangerously contaminated territories. Pollution of more than 1 Ci per square kilometer spread to 9% of the territory of Ukraine, among which 18 out of 25 regions of Ukraine with a total area of 42 thousand square kilometers. 5 million hectares of land were withdrawn from agricultural practice.

As a result of radioactive decay, exposure to rain and wind, human activities and countermeasures, the surface contamination of urban areas with radioactive material was significantly reduced. However, as a result of the decontamination of urban areas, significant volumes of low level radioactive waste were generated, which, in turn, created the problem of their disposal.

After the Chornobyl accident, the highest levels of absorption of radioactive cesium were recorded in forest vegetation and in animals living in forests and hills. In Western Europe, a number of countermeasures are still being applied to livestock products raised on higher elevations and in wooded areas due to the high and sustained absorption of radioactive cesium by the affected extensive farming systems.

The environmental response to the Chornobyl accident was a complex interaction of factors such as the accumulated dose, dose rate, and its temporal and spatial variations. Both individual and group effects caused by radiation–induced cell death were observed in plants and animals as follows:

a) increased death of conifers living in the soil of invertebrates and mammals;
b) loss of reproduction in plants and animals;
c) chronic radiation syndrome in animals (mammals, birds, etc.).

The use of wood and wood products makes only a small contribution to the dose of the population, although the ash may contain large 137Cs activities and potentially lead to higher doses than with other uses of the tree. Forest fires increased the concentration of radionuclides in the air in 1992 and represent the danger of the involvement of radionuclides in the circulation of substances to this day.

High concentrations of radioactive substances in surface waters immediately after the accident quickly declined, and at present, the concentration of radionuclides in drinking water and in irrigation water is very low. However, the groundwater in the region of the accident is close to the surface, so the Chornobyl radionuclides in the coming years after the accident ended up in the groundwater of other European countries. Bioaccumulation of radioactive cesium in the aquatic food chain has led to significant concentrations of radionuclides in fish in the most affected areas, as well as in some lakes located at a great distance, for example, in Scandinavia and Germany.

7. Labor protection and civil defense

An important part of the Chornobyl curriculum is related to the study of some issues on the basics of occupational safety and health. A comprehensive and consistent set of safety requirements sets out the mandatory requirements that must be met to protect people and the environment at present and in the future. Such requirements are governed by the objectives and principles of the security framework. If the requirements are not met, steps must be taken to achieve or restore an adequate level of security. The format and style of the requirements form the basis of a national security regulatory system. The requirements are defined by the relevant parties such as: – State, legal and regulatory basis for security; – Safety management and management; – Radiation protection and safety of radiation sources; – Assessment of the safety of nuclear installations and their operation; – Management of radioactive waste before long–term storage; – Decommissioning and decommissioning of nuclear facilities; – Emergency preparedness and response, etc.

The designs of many existing nuclear power plants, as well as the designs of new nuclear power plants, have been refined by incorporating additional measures to mitigate the consequences of complex accident scenarios, including dependent failures and severe accidents. Many existing NPPs have been additionally equipped with additional systems and equipment with new functionalities designed to help prevent severe accidents and mitigate their effects. According to the requirements of the International Atomic Energy Agency (IAEA), full–scale simulators were created at all Ukrainian NPPs with mathematical modeling of processes, including emergency ones, where operational personnel are trained and tested. New NPP projects now directly include analysis of severe accident scenarios and strategies for managing such accidents. The design of nuclear power plants is also guided by the requirements relating to the state system of accounting and control of nuclear materials and the requirements related to ensuring physical security.

In order to achieve the highest possible level of safety in the NPP project, it is necessary to provide for such measures that meet national and international criteria and security objectives for:

a) the prevention of accidents with adverse effects resulting from the loss of control of the reactor core or other sources of radiation, and the mitigation of any accidents in the event of their occurrence;
b) ensuring that any radiological consequences of any accident involved in the design of the installation are below their respective limits and kept at a reasonably low level;
c) ensuring that the likelihood of an accident with serious radiological consequences is extremely low and that the radiological consequences of such an accident are mitigated as far as practicable.

8. Alternative energy

After the world felt the whole danger of nuclear energy and became infected with the idea of getting energy from alternative sources, such as sunlight and wind, a river of funding surged in that direction.

But what are alternative energy sources? And why are they called alternative? Is it all cloudless on the horizon of owners of miracle equipment capable of giving free energy? A whole series of issues related to the use of alternative energy technologies more and more often arises in a simple person who is thinking about abandoning traditional sources of energy. After all, it would seem how cool it is to completely switch to an inexhaustible natural resource and forget about gasoline exhausts under the window, endless bills and dependence on a thousand and one companies sending these bills! However, in any serious business, there are pitfalls, and it would be nice to identify them in advance, before setting sail.

Alternative sources of energy are called methods of generating heat and electricity using inexhaustible natural resources – sunlight, wind and other gifts of nature.

One of the most common ways to use natural energy is solar panels, replenishing your charge from the rays that hit them. Enterprising representatives of the human race have learned to embed such batteries not only in electrical appliances, but also in tiles, fountains, portable chargers, car roofs, road surfaces and even aircraft. One of the main advantages of solar energy is its environmental friendliness. True, silicon compounds can cause little harm to the environment, but compared with the consequences of burning natural fuels, such damage is a drop in the ocean.

Semiconductor solar cells have a very important advantage – durability. Despite the fact that caring for them does not require especially great knowledge from the staff. As a result, solar panels are becoming increasingly popular in industry and everyday life.

A few square meters of solar panels may well solve all the energy problems of a small village. In countries with a large number of sunny days – the southern part of the USA, Spain, India, Saudi Arabia and others – solar power plants have long been operating. Some of them reach quite impressive power.

Today, projects are already being developed to build solar power plants outside the atmosphere – where the sun's rays do not lose their energy. Radiation trapped in the Earth’s orbit is proposed to be transferred to another type of energy – microwaves – and then sent to the Earth. All this will be memorized fantastically, but modern technology allows such a project to be implemented in the very near future.

Geothermal energy is a method of generating electricity by converting the Earth's internal heat (the energy of hot steam–water sources) into electrical energy. This method of generating electricity is based on the fact that the temperature of the rocks increases with depth, and at a level of 2–3 km from the Earth's surface exceeds 100 ° C. There are several schemes for generating electricity at a geothermal power plant. Direct scheme: natural steam is piped to turbines connected to electric generators. Indirect scheme: steam is preliminarily (before it enters the turbines) cleaned of gases that cause the destruction of pipes. The cost of the “fuel” of such a power plant is determined by the cost of productive wells and a steam collection system and is relatively low. The cost of the power plant itself is low, since it does not have a furnace, a boiler plant and a chimney. The disadvantages of geothermal electrical installations include the possibility of local subsidence of soils and the awakening of seismic activity. And the gases escaping from underground can contain toxic substances.

Wind energy is a branch of energy specializing in the use of wind energy (kinetic energy of air masses in the atmosphere). Wind farm – a facility that converts the kinetic energy of the wind into electrical energy. It consists of a wind turbine, an electric current generator, an automatic device for controlling the operation of a wind turbine and a generator, facilities for their installation and maintenance. To obtain wind energy, different designs are used: multi–blade “daisies”; propellers like airplane propellers; vertical rotors, etc. The production of wind power plants is very cheap, but their power is small, and their work depends on the weather. In addition, they are very noisy, so large wind farms even have to be turned off at night.

Wave energy is a method of generating electrical energy by converting the potential energy of the waves into the kinetic energy of the pulsations and arranging the pulsations into a unidirectional force that rotates the shaft of the generator. Compared to wind and solar energy, wave energy has a much greater specific power. So, the average power of the waves of the seas and oceans, as a rule, exceeds 15 kW/m. With a wave height of 2m, the power reaches 80 kW /m. That is, during the development of the surface of the oceans there can be no shortage of energy. Only part of the wave power can be used into mechanical and electrical energy, but the conversion coefficient for water is higher than for air – up to 85 percent.

Tidal energy, like other forms of alternative energy, is a renewable source of energy. This type of power plant uses tidal energy to generate electricity. For the construction of a simple tidal power station, a pool is needed – a bay covered by a dam or a river mouth. The dam has culverts and installed hydraulic turbines that rotate the generator. During high tide, water enters the pool. When the water levels in the basin and the sea become equal, the gates of the culverts are closed. With the onset of low tide, the water level in the sea decreases, and when the pressure becomes sufficient, the turbines and the electric generators connected to it begin to work, and the water gradually leaves the pool. It is considered economically feasible to build tidal power plants in areas with tidal sea level fluctuations of at least 4 m. The disadvantage of tidal power plants is that they are built only on the shores of the seas and oceans, and besides, they do not develop very large capacity, and tides are only twice a day.

Biomass energy. When rotting biomass (manure, dead organisms, plants), biogas with a high methane content is released, which is used for heating, generating electricity, etc. There are enterprises (pigsties and cowsheds, etc.) that themselves provide themselves with electricity and heat due to that have several large "tanks", where large masses of manure from animals are dumped. In these sealed tanks, the manure rots, and the gas released goes to the needs of the farm. Another advantage of this type of energy is that as a result of the use of wet manure for energy, the dry residue from manure remains, which is an excellent fertilizer for fields. Also, fast–growing algae and some types of organic waste (stalks of corn, reed, etc.) can be used as biofuels. Such alternative sources have several advantages over traditional methods of energy production:

a) environmental friendliness; when using the equipment there are no emissions of harmful substances polluting the environment;
b) noiselessness (this item does not apply to the version with windmills);
c) the ability to install in remote places of the planet, not equipped with power lines;
d) free energy.

Given all the expected costs, the use of an alternative energy source in private ownership is often unprofitable and represents economic benefits only for large enterprises.

Progress does not stand still – polymer solar panels have already been invented, the production of which is several times cheaper. But this does not mean that homeowners should abandon the idea of using alternative energy sources. After all, progress does not stand still – polymer solar cells have already been invented, the production of which is several times cheaper than the manufacture of traditional silicon. And the appearance on the market of new, more economical, models of generators and additional equipment, a change in electricity tariffs gives reason to think that in the near future this practice will still be universally recognized.

9. Conclusions

The educational project aims to motivate senior students to study natural sciences.

To prevent and solve such problems, a large number of qualified specialists of engineers, technologists, and designers are required whose knowledge is based on mathematics, physics, chemistry and other natural and technical sciences. Nowadays, such specialists are becoming less and less every year.

The main objective of the project are:

a) popularization and motivation to study in the natural–mathematical and engineering technical sciences and specialties;
b) preparing a new generation capable of accepting the challenges of the future and creating new safe technologies not only in the energy sector, but also in other areas.

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