Review of the main types of renewable energy sources, their technological essence and trends in technology development.

Problems of measuring the efficiency of renewable energy sources

Since we are talking about energy technologies, attention should be paid to their main technical and economic parameters. In many works and in popular articles, the value of efficiency (efficiency coefficient) is used. However, this indicator is not very informative regarding energy sources.

For example, is it so critical that the efficiency of a photovoltaic converter is 1% (of course, this value is conditional), that is, 99% of solar energy is lost without a trace, even if we consider the Sun to be an infinite and inexhaustible source of energy? What is more important is how the energy produced by this device over its entire life cycle (LC) and the energy spent on its production and operation are correlated. Therefore, in modern studies devoted to the development of alternative energy technologies, instead of the "traditional" indicator - efficiency - an indicator is used, which is the ratio of received useful energy to spent energy (energy retailed on energy invested, EROEI):

In the numerator of the fraction the energy is obtained from the LC and in the denominator the spent energy.

$$EROEI = \frac{EnergyReturned}{EnergyExpanded}$$

Coefficient of net "output" of energy:

Net "output" of energy, that is, in some sense, "energy profit" for the source's life cycle (then NEG is similar to cost efficiency).

$$NEG = \frac{NetEnergy}{EnergyExpanded}$$

$$NetEnergEnergyReturned - EnergyExpanded$$

$$EROEI = NEG + 1$$

It is obvious that:

and the interpretation of their values is similar to the interpretation of financial indicators the index of profitability.

For example, if the EROEI indicator = 5 for a given energy technology, it means that one unit of energy was spent on the production of four units of useful energy.

If the EROEI indicator of a given energy source is equal to or less than one, this means that this source is nothing more than an "energy sink", and its use as a primary energy source is not appropriate.

The value of the EROEI coefficient for different primary energy sources:

Source type	Year of EROEI calculation	EROEI value
Oil and gas	1930	> 100
Oil (average)	1999	35
Natural gas (average)	2005	10
Coal	2000	80
Atomic		5-15
Hydro		> 100
Windy		18
Solar cells (photoelectric)		6,8
Ethanol (sugar)		0,8-10
Ethanol (corn)		0,8-1,6
Biodizel		1,3

The informativeness of the EROEI indicator cannot be considered exhausted, since, in addition to purely "energy efficiency", its convenience - transportability, stability - is of great importance when using one or another primary energy source. So, for example, oil and liquefied gas are convenient to transport and store, but wind and solar energy are unstable. In addition, when calculating EROEI, a fundamental question arises: is it necessary to take into account in the amount of energy spent the energy that was spent on the exploration of deposits, the production of equipment and vehicles for the installation of drilling rigs, wind generators, solar collectors, and the disposal of waste from nuclear power plants? And should we take into account the energy spent on the vital activities of workers, engineers, as well as those workers who provided them with the necessary goods and services? In other words, to what level of the production chain must be reached when calculating the EROEI indicator?

One way or another, despite the current lack of a single methodology for calculating the EROEI indicator and its other shortcomings, it is difficult not to admit that it is more informative for assessing the efficiency of energy technologies than the indicator, efficiency, which is traditionally used in this field.

Particular attention is paid to another physical characteristic that determines the efficiency of energy technologies - energy density. For example, the density of solar energy reaching the Earth's surface is quite high, but the low efficiency of photovoltaic converters combined with the high energy consumption of their production reduces the efficiency of the corresponding technologies. As for, for example, the energy of sea waves, tides and tides, despite the gigantic energy potential of these sources, they have a low energy density, that is, the devices that capture it (tidal turbines) must have large dimensions, which also predictably affects their efficiency.

Our goal of considering this topic is an overview of the trends in the development of "green" technologies. As will be shown below, even if certain "green" technologies do indeed provide the claimed efficiency, this does not mean that they are not good from a socio-economic and environmental point of view.

The city of new energy sources in the world energy balance.

Global investment trends indicate a likely increase in the share of renewable energy sources in the structure of the global energy system in the coming decades.

In the scenarios of the world energy development of the International Energy Agency (IEA), there are two alternative options - a scenario of development with the inaction of national governments and other regulatory institutions, and a scenario of development with the active application of management influences on producers and consumers of energy to achieve the set goals - reducing CO2 emissions by 2050 twice compared to 2005.

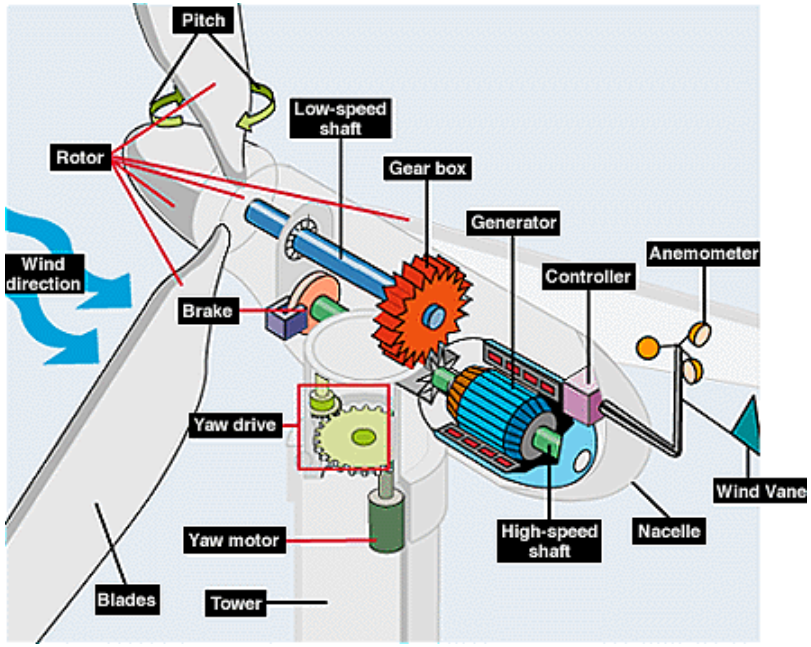
Investments in new energy technologies.

According to estimates for the years 2010-2015, in order to limit greenhouse gas emissions to the level necessary to keep warming within the target of 2°C (the target level adopted in the Copenhagen Accord), an additional global investment of $440 billion will be required annually .

Global market of wind energy and equipment for wind energy.

In recent years, the global market for equipment for the production of wind energy has continued to grow steadily. Production of new wind turbines in 2009 increased by 42.1%. In 2009, the volume of the world market for wind energy equipment reached 50 billion euros, in which the share of Europe is dominant (47.9% of all installations).

Wind energy.



Wind power plants (WPPs) are classified as:

- according to the type of energy produced (mechanical and electrical);

- by power (high power: over 1 MW, medium power: from 100 kW to 1 MW, low power: from 5 to 99 kW, very low power: up to 5 kW).

Mechanical wind turbines are classified according to application areas (wind pump, wind power), and electric wind turbines are divided into direct current and alternating current wind turbines.

Wind-pump wind turbines are used for irrigation, water supply, land drainage, water lifting and other works. Wind turbines are used for the mechanization of labor-intensive processes of agricultural and other works.

The capacity of the currently largest wind turbines reaches 6 MW. the diameter of the rotor of such a turbine is 126 meters, the weight of the gondola is 200 tons, the height of the tower is 120 m.

Basics of wind energy.

Winds appear due to uneven heating of the atmosphere by the sun, unevenness of the earth's surface and the rotation of the Earth. The direction of wind flows varies depending on the topography of the earth's surface, the presence of water bodies and vegetation.

Wind turbines use this air movement and convert it into mechanical energy and then into electricity.

People began to use wind energy several centuries ago, when windmills appeared that pumped water, ground grain, or performed other functions. Today's wind generator is a very advanced version of a windmill.

When the wind passes through the turbine, the blades begin to rotate due to the kinetic energy of the wind. This causes the inner shaft to rotate, which is connected to a gearbox that increases the speed of rotation and is connected to a generator that produces electricity.

Advantages and disadvantages of wind energy.

Renewable energy source.

Wind energy is a publicly available, renewable resource, so no matter how much is used today, it will still be available in the future. Wind energy is also a source of relatively clean electricity - wind farms do not emit air pollutants or greenhouse gases.

Cost.

Even though the cost of wind energy has fallen dramatically over the past 10 years, its use requires a larger initial investment. than purchasing fossil fuel generators. About 80% of the cost is equipment, with site preparation and installation. However, if you compare the use of a wind generator and a fossil-fueled installation over the entire period of operation, then the wind energy installation becomes much more competitive, because it does not require the purchase of fuel, and operating costs are minimized.

Impact on the environment.

Although wind farms do not have as much of an impact on the environment as fossil-fueled power plants, they do present some challenges. their blades create noise, visually they can spoil the landscape, birds crash into them. Most of these problems are solved to one degree or another due to various technologies and intelligent placement of power plants.

Other problems related to wind turbines.

The main problem associated with the use of wind energy is that the wind is not always there when electricity is needed, in some areas the winds are weak, so it is not profitable to use wind generators there. Wind cannot be stored like gasoline (although electricity generated from wind can be stored using a battery). Areas with strong winds are often not very convenient for settlement. Finally, wind energy installations can create problems for other ways of exploiting the land.

Solar energy.

Solar energy is a field of energy related to the conversion of solar energy into electrical and thermal energy. Due to the wide variety of existing methods of energy conversion, several main types of solar power plants are distinguished.

A solar power plant (SPP) is a power plant designed to convert the energy of solar radiation into electrical energy. Solar-fuel power plant (SFPP) is a power plant that converts the energy of solar radiation and the chemical energy of fuel into electrical and thermal energy according to a single technological scheme.

All SPP and SFPP work on solar cells. A solar cell is a converter of the energy of solar radiation into electrical energy, made on the basis of various physical principles of direct conversion. To date, the most common solar photovoltaic elements operating on the basis of the photoeffect. However, other types of solar cells are also used, for example, thermoelectric ones, which work on the basis of thermoelectric phenomena, in which the source of heat is the energy of solar radiation.

Photoelectric batteries are still the simplest, most reliable and cost-effective system for obtaining solar electricity. The thickness of the semiconductor layers is no more than two or three tenths of a millimeter. All over the world, active research is currently being conducted to create thin-film photovoltaic panels. The technology of converting sunlight into electricity in thin-film and conventional photovoltaic panels is the same, but the former are much thinner and more flexible than conventional ones due to the polymer, not glass substrate.

Solar energy is energy that is produced in the sun in the form of heat and light. It is one of the most renewable and readily available sources of energy. The fact that sunlight and heat are freely available, abundant, and owned by no one makes them one of the most important alternative energy sources.

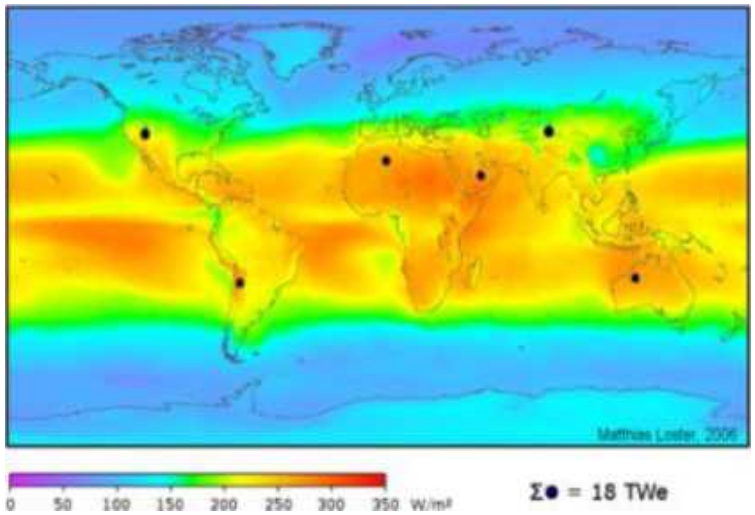
Impact on the environment.

Though. Although solar energy is a renewable resource and is considered one of the cleanest sources of energy available, it still has an impact on the environment. To obtain electricity from solar energy, photocells are used, their production is associated with the production of waste. Improper management of these materials can lead to the risk of hazardous effects on humans and the environment. Installing solar power plants can require a large area, and shielding the earth's surface can affect existing ecosystems.

The future of solar energy.

In the future, thanks to new developments that should lead to lower costs and higher efficiency, solar technology will be much more important than it is now. There are more and more solar chargers for mobile devices.

The cost of solar panels has decreased 100 times over the past 35 years.



Map of solar radiation.

Heliothermal energy - heating of a surface that absorbs solar rays, and subsequent distribution and use of heat (focusing solar radiation on a vessel with water for further use of heated water for heating, hot water supply or in steam generators). It is customary to single out solar systems (CSP - Concentrated solar power) as a special type of heliothermal power stations. In these installations, the energy of the sun's rays is focused into a concentrated beam of light using a system of lenses and mirrors. This beam is used as a source of thermal energy to heat the working fluid.

The flux of solar radiation passing through an area of 1m2, located perpendicular to the flux of radiation at a distance of one astronomical unit from the center of the Sun (at the entrance to the Earth's atmosphere), is equal to 1367 W/m2 (solar constant). Due to absorption, when passing through the Earth's atmospheric mass, the maximum flow of solar radiation at sea level (at the Equator) is 1020 W/m2. However, it should be taken into account that the average daily value of the flow of solar radiation through a single horizontal platform is at least 1 times less (due to the change of day and night and the change of the angle of the sun above the horizon). In winter, in temperate latitudes, this value is two times smaller.

Advantages.

• Perspective, availability and inexhaustibility of the energy source in the conditions of constant growth of prices for traditional types of energy carriers;

• Theoretically, complete safety for the environment.

Disadvantages.

• Dependence on weather and time of day;

• Seasonality in mid-latitudes and divergence of periods of energy production and energy needs. Unprofitability in high latitudes, the need for energy accumulation;

• During industrial production - the need to duplicate solar • traditional power plants of comparable capacity;

• High construction cost associated with the use of rare elements (for example, indium and tellurium);

• Necessity of periodic cleaning of the surface from contamination;

• Heating of the atmosphere above the power plant;

• The need to use large areas;

• The complexity of production and disposal of the photocells themselves due to the content of poisonous substances in them, for example, lead 5 cadmium, gallium, arsenic, etc.

Development of small hydropower and geothermal energy.

Small hydropower can be considered as one of the oldest directions in alternative energy in the whole world.

At the same time, the current level of development of small hydropower in the world is quite high. The total capacity of installed MHPs in the world in 2009 was estimated at more than 75 GW. The leader among the regions of the world in energy production from small hydropower plants is Asia, primarily due to such countries as China and India.

Small hydropower.

Small hydropower is often classified as an alternative method of energy generation, as it is free from many of the disadvantages of large hydroelectric power stations and is recognized as one of the most economical and environmentally safe ways of obtaining electricity, especially when using small watercourses. The fundamental difference between small power generation and conventional power generation is the absence of the need to build large hydrotechnical facilities (dams, reservoirs), which simplifies construction and licensing.

During the construction and operation of small hydropower plants, the natural landscape is preserved, and there is practically no load on the ecosystem. The advantages of small hydropower - compared to fossil fuel power plants - include the low cost of electricity and operating costs, relatively inexpensive replacement of equipment, long service life of hydropower plants (up to 40-50 years), integrated use of water resources (power, water supply, reclamation , water protection, fisheries).

Geothermal energy - obtaining thermal or electrical energy due to the heat of the earth's depths. Geothermal sources, according to the classification of the International Energy Agency, are divided into 5 types:

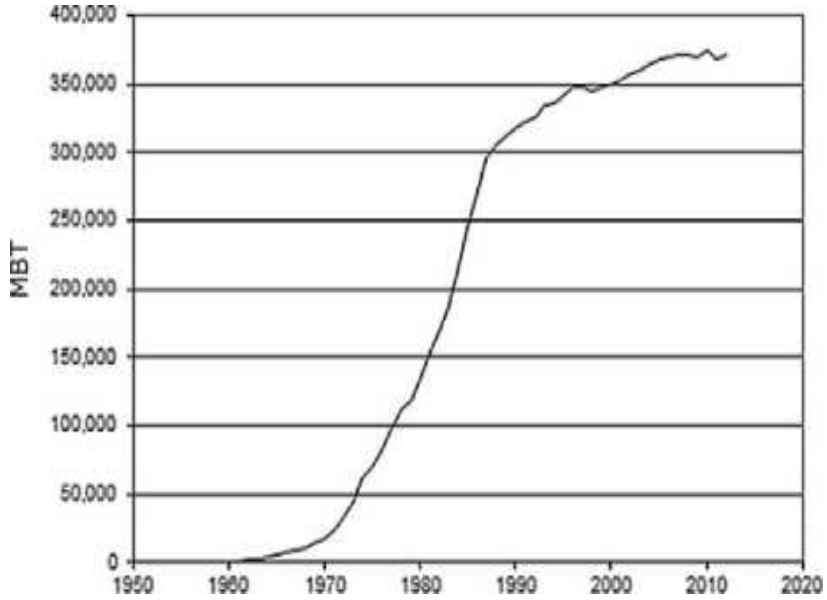
- **deposits of geothermal dry steam;**
- **sources of wet steam (mixtures of hot water and steam);**
- **geothermal water deposits (containing hot water or steam and water;**
- **dry hot rocks heated by magma (at a depth of 2 km or more);**
- **magma, which is molten rock heated to 1300 ° C.**

The greatest economic efficiency of the use of geothermal energy is achieved in areas where hot water is close to the surface of the earth's crust - in areas of active volcanic activity with numerous geysers. It is widely used in the Philippines (the share in the country's energy balance is 19%), in Mexico (4% of all energy used) and in the USA (taking into account the use "directly" for heating - about 1%).

World nuclear power plants (npp). Atomic energy production.

The first production of electricity using a nuclear reactor (Experimental Breeder Reactor EBR-I) was carried out in 1951 in the USA. This generator was not intended to produce electricity, but it was connected to four lamps to test its performance.

According to the data of the International Atomic Energy Agency IAEA in 2014, the world functions 435 nuclear power units with an installed net capacity of 372 GW, 72 reactors in 15 countries with an installed capacity of 68 GW are under construction.



World capacity produced at nuclear power plants.

Processing of materials.

Battery (fr. Batterie) - two or more electrical elements connected in parallel or in series. Usually, this term refers to the connection of electrochemical sources of electricity/electric current (galvanic cells, batteries, fuel cells).

Batteries play an important role in our lives, and everyday things are now simply unthinkable without them. We depend on the good and reliable operation of batteries, so that they work stably, you need to know what properties they have and how to handle them.

The principle of operation of the battery is based on the reversibility of the chemical reaction. The capacity of the battery can be restored by charging, that is, by passing an electric current in the direction opposite to the direction of the current during discharge. Several batteries connected in one electrical circuit make up a battery.

The parallel connection of electrochemical elements in the battery increases the total capacity of the battery, increases the maximum output current and reduces its internal resistance.

Laptop battery device. 10.8 V (3 parallel-connected pairs of Li-ion batteries of 3.6 V connected in series).

Accumulator batteries of the backup power source of the data center.

Electric bus batteries.

An electric battery is a chemical source of current, a source of multiple action, the main specificity of which is the reversibility of internal chemical processes, which ensures its repeated cyclic use (through charge-discharge) for energy storage and autonomous power supply of various electrical devices and equipment, as well as for providing backup energy sources in medicine, production, transport and other areas.

Nickel cadmium (NiCd) batteries.

It is one of the oldest and well-studied battery systems. These power supplies are used there. where long service life, high discharge current, extreme temperatures and low cost are required. Due to the fact that NiCd batteries cause significant damage to the environment, they are replaced by other types of systems. In Europe, it was forbidden to sell consumer goods with these types of batteries. The main areas of application: power tools, walkie-talkies, aviation transport.

Lithium-ion (Li - ion) batteries

The most promising type of battery systems; used in portable consumer products and electric vehicles. Li-ion batteries are sensitive to overvoltage during charging and, to ensure safety, a protective circuit is added to them, but not always. These types of batteries are more expensive than the ones described above.

A lithium-ion battery consists of electrodes (cathode material on aluminum foil and anode material on copper foil) separated by an electrolyte. The charge carrier in a lithium-ion battery is a positively charged lithium ion, which is introduced into the crystal lattice of other materials to form a chemical bond.

Self-discharge is the battery's loss of charge after full charging in the absence of load. Self-discharge manifests itself differently in different types of batteries, but it is always maximal in the first hours after charging, and then it slows down.

For Ni-Cd batteries, no more than 10% self-discharge in the first 24 hours after charging is considered acceptable. In Li-ion, it is extremely small and manifests itself significantly only within a few months after charging.

Several methods are used to charge batteries; as a rule, the charging method depends on the type of battery.

Lithium-ion batteries are often exposed to the adverse effects of high temperatures. they are often used in mobile phones, which get very hot in the sun in the summer, and in laptops they are constantly connected to the power grid. Increased temperatures and constant recharging from the network, when the battery has maximum stress for a long period, explain the shortening of the service life of batteries in mobile devices. High temperature and overcharging also have a bad effect on lead and nickel batteries. All batteries need to "rest" after charging.

Lithium-ion batteries must be stored in a charged state. Ideally, the charge level should be 40%. This ensures that the self-discharge voltage does not fall below 2.50 V / cell.

Recycling of accumulators and batteries.

Recycling of accumulators and batteries is a problem that is now faced by all countries of the world. The main purpose of recycling batteries is to prevent hazardous substances from entering the environment. Lead-acid and nickel-cadmium batteries are particularly dangerous. Do not store old lead-acid batteries at home, especially where children play. Even a simple touch to the poles can be dangerous.

Only 3% of the world's production of batteries and accumulators is recycled, while some countries do more recycling, while others do not at all. In the USA, about 60% of batteries are recycled (20-40% lithium-ion and 97% lead-acid), in most European countries 25-45% are recycled, in Australia - about 80%. In developing countries, they are practically not engaged in recycling and batteries are thrown away with ordinary household waste.

Despite the fact that lead-acid batteries are environmentally dangerous, they account for a considerable share of the market. Nickel-cadmium batteries also continue to hold the leading position among batteries. In Europe, it was forbidden to sell consumer goods with nickel-cadmium batteries, as they can be replaced with nickel-metal hydride batteries. If they are part of consumer goods, it is very difficult to manage their disposal, since many users simply do not know what is inside the devices.

Battery recycling is a very energy-intensive process, in which 6 to 10 times more energy is used to extract the metals than it takes to produce the materials in other ways, including the mining industry. A natural question arises: "Then who pays for the recycling of batteries?"

When batteries are produced in the European Union, their cost first takes into account disposal costs. The buyer in the store receives a discount on new batteries by handing in old batteries.

Charger - an electronic device for charging electric accumulators and storage batteries with energy from an external source; as a rule, from the alternating current network.

It includes a voltage converter (transformer or pulse power supply unit), a rectifier, a voltage stabilizer, and, if necessary, a charge process control device, indicating devices (arrow or LED ammeter / voltmeter).

Characteristics of chargers depend on the type of batteries, operating voltage, nominal capacity. Chargers can be built-in or external.

Wireless charger / Inductive charger has been used since the late 2000s, in many mobile devices. It is also used in electric vehicles.

Inductive charging is a type of wireless energy transfer. It uses electromagnetic induction to supply power to portable devices. The Qi wireless charging standard is most often used for smartphones, smart watches and tablets. Inductive charging is also used in vehicles, power tools, electric toothbrushes and medical devices.

Portable equipment can be placed next to a charging station or induction pad without the need for precise alignment or electrical contact with the station.

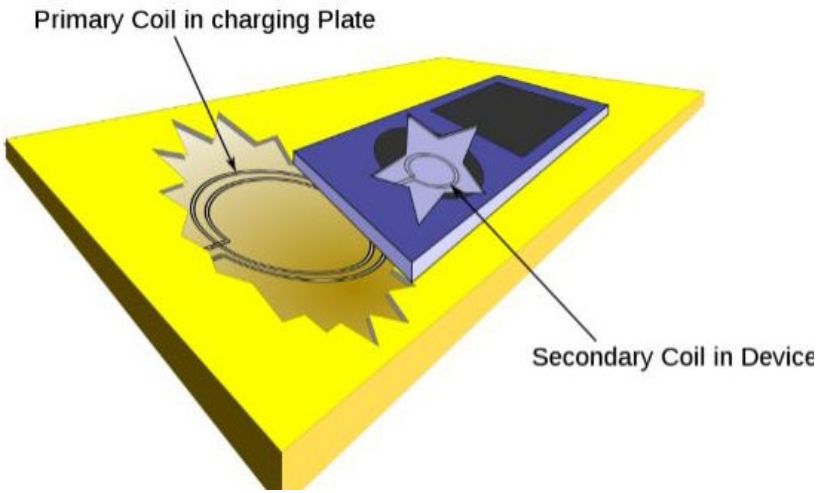
Nowadays, it is difficult for us to imagine our life without mobile gadgets. This led to the fact that a huge number of wires accumulate near home sockets, among which it is not so easy to find the necessary "charging". In this case, a wireless charger will help solve the problem. The principle of its operation is very simple - it is enough to place the gadget on a special panel for it to charge. The accessory is based on the principle of the induction coil. This technology is called Qi.

It is becoming very popular recently. In 2015, the world-famous brand began selling furniture with a built-in wireless charging module. Today, all flagship smartphone models support Qi. It is expected that soon transmitters or, in other words, modules can be found in airports, restaurants, cinemas, fast food, shopping centers, which will allow charging of phones and tablets at any time. In fact, it will make life easier for users of mobile gadgets. We are entering a new era where it is not at all necessary to carry around wired chargers for all the devices we use.

Some users mistakenly believe that the Qi wireless charging function can be harmful to health. The fact is that magnetic radiation is not ionizing. In terms of its effect on the body, it is similar to a mobile phone signal, a Wi-Fi signal, and a radio signal. At the same time, the mobile network signal coming from the tower is stronger and has a continuous character, while the electromagnetic radiation disappears immediately after charging the smartphone battery.

The power of wireless chargers is 5W. It is not enough to affect the human body. We can talk about a negative impact only if the power of such devices is equal to 120 W. But similar models are not produced on an industrial scale. This explains the lack of wireless chargers for laptops. It is important to know that the technology of wireless battery charging has long been used in many models of electric shavers and electric toothbrushes, which once again proves its safety.

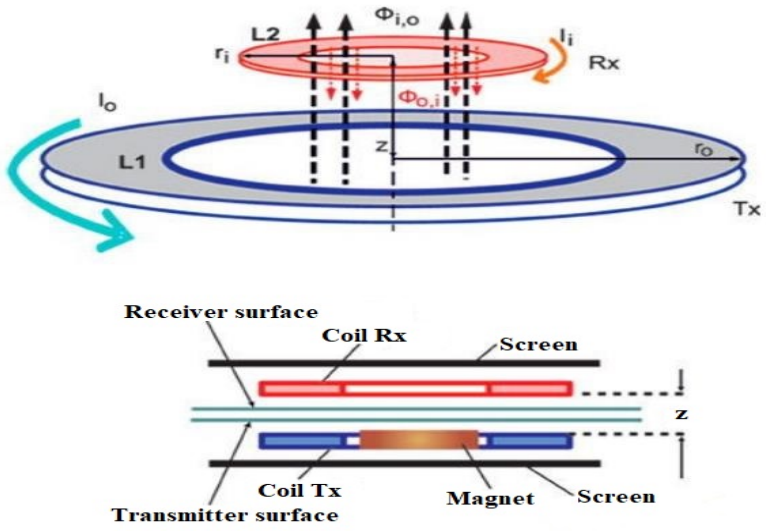
Wireless Power Transfer (WPT) or electromagnetic power transfer is the transmission of electrical energy without wires as a physical communication channel. In a wireless energy transfer system, a transmitting device powered by electricity from a power source generates a time-varying electromagnetic field that transmits energy in space to a receiving device that takes energy from the field and transmits it to the electrical network.



The primary coil of the charger induces a current in the secondary coil of the charging device.

The technology of wireless energy transmission allows you to abandon the use of wires and batteries, thereby increasing the mobility, convenience and safety of the electronic device for all users. Wireless power transmission is useful for powering electrical devices where connecting wires are inconvenient, dangerous, or impossible.

Wireless power methods are mainly divided into two categories: near field and far field. In near-field or nonradiative methods, energy is transferred over short distances using magnetic fields using inductive coupling between turns of wire or electric fields using capacitive coupling between metal electrodes. Inductive communication is the most widely used wireless technology; its applications include charging of portable devices such as phones and electric toothbrushes, induction cooking, and wireless charging or continuous wireless power transfer in medical devices such as artificial cardiac pacemakers or electric vehicles.



An inductive charging pad for a smartphone as an example of wireless transmission data in the near zone. When the phone is on the stand, a coil in the tablet creates a magnetic field that induces a current in the phone's other coil, charging its battery.

UTILIZATION

E-waste is used electrical or electronic devices. Used electronics intended for repair, reuse, resale, recycling through material recovery or disposal are also considered e-waste. Informal processing of e-waste in developing countries can lead to adverse consequences for human health and environmental pollution.

Electronic scrap components such as processors contain potentially harmful materials such as lead, cadmium, beryllium. Recycling and disposal of e-waste can be associated with a significant risk to the health of workers.

E-waste or e-waste is generated when an electronic product is discarded after its useful life has expired. The rapid spread of technology and society driven by consumption lead to the creation of a very large amount of e-waste every minute.

Disposal of electronic components is an important environmental aspect of information systems. Almost all PC hardware contains harmful substances. Components of information systems also contain toxic substances.

There are standards that are aimed at solving the problems of e-waste.

Even when designing an information system, it is necessary to take into account the future disposal of its components.

In general, the following processes are implemented during the liquidation of information systems:

- **reuse;**
- **transmission to other users;**
- **charity;**
- **restoration;**
- **replacement of component parts;**
- **liquidation (destruction and processing of electronic waste).**

E-waste is increasing. Many negative effects are gradually manifested in relation to the environment. Many toxic substances (heavy waste and refractory plastics) contain waste. which are easily formed in groundwater.

Processing e-waste to obtain raw materials is expensive, so more emphasis has been placed on disassembling machines and reusing or refurbishing their individual components. Meanwhile, many communities have banned the disposal of e-waste in the regular garbage, and some of them are opening options to refuse e-waste.

Some of the main environmental impacts of e-waste are:

The damage caused by the heating of e-waste, with the emission of toxic chemicals into the air and damage to the atmosphere, is one of the most serious environmental consequences of e-waste. This will lead to a number of airborne diseases and increase the toxicity of the air, making it unfit for breathing and living.

E-waste, which is often dumped in landfills, releases toxins that seep into groundwater. It affects: both terrestrial and marine animals. Especially in developing countries, where a large part of e-waste is dumped in landfills, it also affects people's health. This soil pollution will also lead to the loss of vegetation and harm the ecosystem.

Solar batteries for a smart home, the main types and analysis of their effectiveness.

Today, solar energy is one of the most ecologically clean ways of obtaining electricity and heat. Interest in this area is growing every year, including from the point of view of autonomous energy supply of a "smart house". Let's analyze in more detail whether solar batteries are profitable in a private house, what types of them are on sale, and the nuances of their use for obtaining electricity and heating premises.

The principle of operation of solar batteries.

The principle of operation of the solar power plant is based on the semiconductor effect. This effect was first discovered by the French physicist Becquerel in the first half of the 19th century. A real working semiconductor was created in 1873, however, until the middle of the 20th century, it was not possible to create an efficiently working solar battery capable of producing a significant amount of electricity.

The basis of the design is silicon, as one of the most efficient semiconductors. Photocells are made from it, which make up the top layer of the battery plates. Under the influence of sunlight in the converter block, the release of negatively charged particles from silicon atoms begins. The released electrons are captured by the atoms of the lower plate. According to physical laws, they tend to return to their original position.

Returning to the upper silicon plate, they move along thin wires, charging part of their energy to a battery connected to the photovoltaic cells. The operation of solar cells created on the basis of the monocrystalline method of applying a silicon layer is much more efficient. This is due to the fact that in this case the crystal lattice formed by silicon has fewer faces, and this gives electrons the ability to move in a straight line.

Classification of solar batteries.

Today, there is a large number of solar energy converters, which are conditionally classified according to several characteristics. According to the amount of electricity produced, solar panels are:

- **Low-power, intended for power supply and recharging of various gadgets (laptops, smartphones, portable devices, small TVs, etc.)**
- **Universal. Capable of providing energy not only low-power devices, but also some household appliances, for example, lighting lamps.**
- **Solar cells consisting of a series of photocells fixed on a substrate. Such panels can be used for the energy supply of a cottage, outbuildings, and a cottage.**

According to their design, electric generators operating on solar energy are divided into:

• Photoelectric. They are a semiconductor structure in which the heat energy of the sun is converted directly into electricity. Several photocells are combined into a single battery that operates on the principle of semiconductors.

• Solar power plants. Generating devices of this type concentrate the energy of the sun, directing it to the movement of turbines. The principle of concentration consists in the use of lenses, or concave mirror surfaces. The sun's rays are directed to a container with a coolant that boils and turns into superheated steam. Next, the steam is passed through the turbines, rotating them and producing an electric current.

• Thermal collectors - solar batteries for heating part of the house. Belong to the class of low-temperature devices. The principle of their operation is simple: the accumulated energy of solar radiation will turn into thermal energy, which is used to heat water in the hot water supply system and the heating circuit of the house. The efficiency of solar batteries of this type directly depends on their area: the larger it is, the higher they heat water.

Solar energy for heating.

One of the areas of application of solar installations in the "smart house" system is space heating in the cold season, as well as heating water used for domestic needs in hot water supply systems. Modern models of solar panels and collectors can function even in winter, when the air temperature drops to -3°C. Thus, they can compete with traditional methods of heating a part of the house.

The principle of operation of panels with photocells

Home heating from solar batteries can be produced in two ways:

1. By the method of direct heating of the coolant in the heating system. It is produced by concentrating the sun's rays on storage tanks, or tubular circuits along which water moves.

2. Using solar panels that generate electricity. In this case, the operation of solar batteries for heating the home is similar to the operation of electricity from the general power grid. Panels with photocells work when heating water in the heating circuit according to the following principle - sets of solar batteries, converting the energy of the sun's rays into electricity, charge the batteries. From them, the current enters the inverters, which will convert it in terms of voltage, frequency, and strength. Therefore, electricity is supplied directly to heating devices, for example, to an electric boiler.

The advantage of solar panels over solar collectors is the ability to accumulate electricity. And this, in turn, allows you to integrate a water heating system based on solar batteries into a "smart house" complex. For this, you can use sensors and relays that independently start electric heating of the heating system when the temperature drops below the set values.

It is also possible to connect external control of the process of maintaining heat in the house using an Internet connection and any gadget that has access to the World Wide Web - smartphone, laptop, PC. The efficiency of using photocells, in comparison with solar collectors, consists in the possibility of autonomous or controlled regulation of their operation. The presence of a rechargeable battery allows you to be less dependent on the whims of the weather, and always maintain a comfortable temperature indoors.

Types of solar batteries

Today, there are several types of solar batteries that differ in their design and operational and technical indicators.

Monocrystalline.

In the manufacture of monocrystalline panels, silicon of a high degree of purification is used. It is possible to obtain such a material only in an industrial way with the use of special technologies. Such solar systems are quite expensive, but they differ in higher efficiency, which is on average 15-20%, and in some cases even reaching 20%.

Polycrystalline.

In these designs, silicon is applied to the base in a polycrystalline manner, which reduces the efficiency of solar cells. The fact is that in such crystal lattices, electrons cannot move in a straight line, and give less charge per unit of time. The method of manufacturing polycrystalline panels consists in applying molten silicon to a support, followed by slow cooling.

Their surface has a bright blue color. Such modifications of solar systems have a lower cost, but their efficiency is also low. The efficiency of polycrystalline panels does not exceed 10-12%. Therefore, to obtain 1 W of electricity, a larger area of photocells will be required than when using monocrystalline batteries. And this negates their main advantage - low cost.

Thin-leaved

Thin-sheet solar panels are made from amorphous silicon deposited on a thin, flexible substrate. From above, the silicon layer is covered with a protective film that protects it from mechanical damage. Such structures have the lowest price per square meter, but, at the same time, the lowest efficiency. The efficiency of gas is only 5-7%. Their service life is also short: later on, their technical qualities decrease even more.

Installation of solar panels on the roof.

The efficiency of solar panels largely depends on their correct placement. When installing a solar battery on the roof of the house, a number of rules should be followed. First, they should be installed from the most illuminated side. Another important parameter is the angle of inclination of the panel in relation to the horizon. Since the sun is at some angle to the earth, its rays also fall at an angle.

Pros and cons of an alternative heating system

A house with solar panels is undoubtedly a high-tech product of scientific and technological progress. However, heating systems based on the use of solar energy have both their undeniable advantages and disadvantages. The advantages include:

environmental friendliness of technology. During the production of "solar electricity", no harmful substances for humans and nature are released.

Complete autonomy. Solar heating installations make it possible to be completely independent of utility services and their seasonal schedule of disconnection and connection of heating.

Absence of bureaucratic problems. For installation and connection of solar power supply systems, it will not be necessary to obtain permits from various authorities.

Will solar panels installed in a private house pay off? The cost of panels is high, and the normal autonomous functioning of a residential building requires a significant area of generating surfaces. As calculations show, they will pay off completely no earlier than three years from the start of use. And that, this is under the condition of active operation and placement in a region with a high level of solar radiation. In areas where the number of clear days is small, the payback period will be even longer. Still, solar energy is currently one of the most promising areas of scientific and technological progress. Thanks to new developments and scientific discoveries, the efficiency of solar energy will grow, and the cost price, on the contrary, will decrease. All this makes the use of solar panels in the "smart house" system quite a correct decision.