UNCONVENTIONAL DRIVE WITH SOLAR PANELS AND WIND GENERATOR OF PCP OIL EXTRACTION FACILITY (PROGRESSIVE CAVITY PUMP)

ACȚIONAREA NECONVENȚIONALĂ CU PANOURI SOLARE ȘI GENERATOR EOLIAN A INSTALAȚIEI PETROLIERE DE EXTRACȚIE CU PCP (POMPĂ CU CAVITĂȚI PROGRESIVE)

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Abstract: *A Progressing Cavity Pump consists of a single helical rotor which rotates inside a double internal helical stator. The rotor is precisely machined from high strength steel. The stator is molded of resilient elastomer. Thus, an interference fit can be obtained. When the rotor is inserted in the stator, two chains of lenticular, spiral cavities are formed. As the rotor turns within the stator, the sealed cavities spiral up the pump without changing size or shape and carry the pumped product. This makes the PC Pump the best pump for viscous fluids. The rotors are plated with a hard material to resist abrasion. Abrasive particles which are caught between the rotor and the stator are pressed into the elastic wall of the stator and then expelled into the next cavity when the rotor has passed. For oil production, the stator is fixed to the tubing and the rotor is attached to a sucker rod string in this paper we present an analysis of theoretical concepts very common nowadays, photovoltaic and wind turbines, but also a practical part where I presented a hybrid (photovoltaic-wind) to power a pump extraction cavitation progressive.*

Keywords: electrical current, wind turbines, wind, pump with progressive cavities.

Rezumat*: O pompă cu cavitate progresivă constă dintr-un singur rotor elicoidal care se rotește în interiorul unui stator dublu elicoidal intern. Rotorul este prelucrat cu precizie din oțel de înaltă rezistență. Statorul este turnat din*

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elastomer elastic. Astfel, se poate obține o potrivire prin interferență. Când rotorul este introdus în stator, se formează două lanțuri de cavități lenticulare, spiralate. Pe măsură ce rotorul se rotește în interiorul statorului, cavitățile sigilate urcă în spirală prin pompa fără a modifica dimensiunea sau forma și transportă produsul pompat. Acest lucru face din PC Pump cea mai bună pompă pentru fluide vâscoase. Rotoarele sunt placate cu un material dur pentru a rezista la abraziune. Particulele abrazive care sunt prinse între rotor și stator sunt presate în peretele elastic al statorului și apoi expulzate în cavitatea următoare când rotorul a trecut. Pentru producerea uleiului, statorul este fixat de tubulatura si rotorul este atasat de un sir de tije de ventuze in aceasta lucrare prezentam o analiza a conceptelor teoretice foarte des intalnite in zilele noastre, turbine fotovoltaice si eoliene, dar si o parte practica in care am prezentat un hibrid. (fotovoltaic-vânt) pentru a alimenta o pompă de extracție a cavitației progresive.

Cuvinte cheie: curent electric,turbine eoliene, vânt, pompă cu cavități progresive.

1. Introduction

The present work proposes, on the one hand, a theoretical analysis of some concepts that are often encountered nowadays - the photovoltaic system and wind turbines, and on the other hand, the highlighting of a practical part in which a hybrid system (photovoltaic - wind) was dimensioned for powering a extraction pumps with progressive cavitation.

From a theoretical point of view, photovoltaics (PV) are semiconductor devices that convert sunlight into electrical current. Photovoltaic groups are electrically configured in modules and arrays that can be used to charge batteries, run motors, and power electrical loads. With the appropriate power conversion equipment, photovoltaic systems can produce alternating current (AC) that is compatible with any conventional appliance. A photovoltaic system (SFV) "*directly converts solar energy into electrical energy, based on the photovoltaic effect, and brings it to the electrical parameters required by the consumer*". Photovoltaic cells can be made of several semiconductor materials, over 95% of solar cells are made of silicon (Si), which is the second most common chemical element in the earth's crust, representing about 25 % of it.

On the other hand, wind turbines are generally used either as a stand-alone battery charging system or in combination with a single-phase inverter to charge loads (lighting, small household appliances). The wind is the result of the energetic activity of the Sun and is formed due to the uneven heating of the Earth's surface. The major wind potential is observed on the sea coasts, in the mountains, but there are many other territories with a wind potential necessary for use. As an energy source, the wind can be more difficult to calculate than the Sun, but in certain periods the presence of the wind is observed during the whole day [1].

The relief of the earth and the presence of barriers (obstacles) placed at heights of up to 100 meters influence wind resources. The evaluation of wind resources for vast areas is done to establish both the available regional resources and to identify the best territories in the respective region. A map of the wind intensity and direction in Romania is shown in (figure 1).

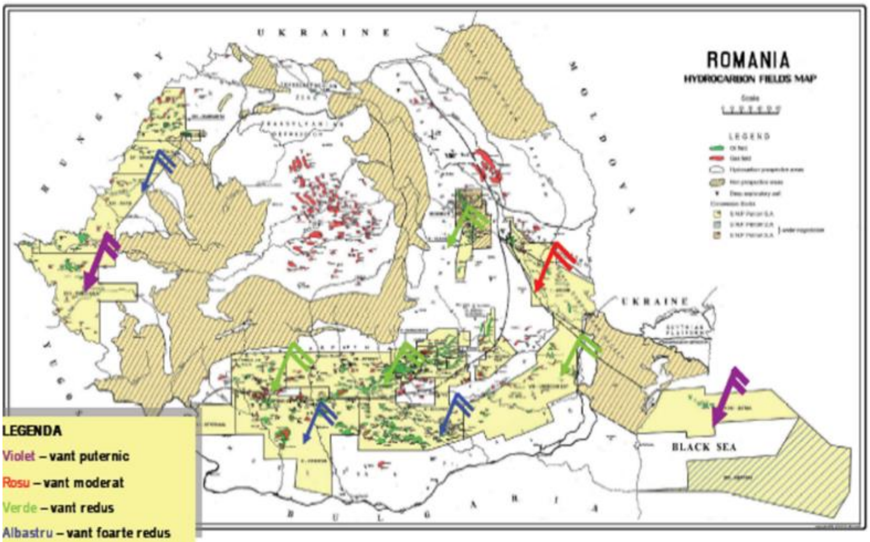

Figure 1 – The wind potential in România.

2. The constructive elements of the wind system

From an energy point of view, a wind system transforms the kinetic energy of the wind into electrical energy (figure 2).Wind speed affects the rpm of the wind turbine in generating the voltage applied to the battery and the inverter. From the measurement of wind turbine output power to there sulting discharge, it is shown that the variation of water discharge issued by the pump varies according to the wind speed at any given hour. As shown in figure 5, the minimum water discharge occurs at 08.00 is 0.09355 l/d, this is due to the unstable voltage of the outflow from the inverter, then the maximum water discharge occurs at 15:00 which is equal to 0.37667 l/d, the voltage generated by the inverter is already slightly stable.

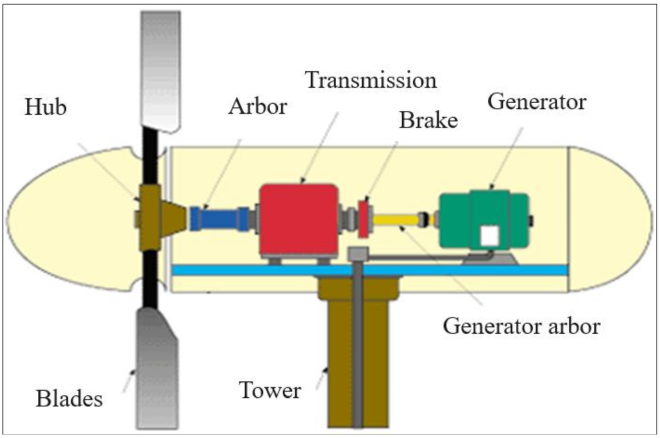

Figure 2 – The components of the wind system

To achieve this conversion, the wind system contains the following components (figure 2):

– The turbine propeller consisting of:

– blades that are made of a mixture of glass fiber and composite materials, with the role of capturing wind energy and transferring it to the turbine rotor;

– hub provided with a passive (aerodynamic), active (hydraulic) or mixed (active stall) system that allows the orientation of the blades to control the rotation speed of the wind turbine;

– The primary shaft is the rotor shaft of the wind turbine. It is also called the slow shaft, because it rotates at speeds of the order of 20 – 40 rpm. Through the multiplier, it transmits the movement to the secondary shaft;

– The mechanical speed multiplier allows the transformation of mechanical power, characterized by high torque and low speeds specific to the wind turbine, into higher speed power, but lower torque. The speed of the wind turbine is too low, and the torque too high, to be applied directly to the electric generator. The multiplier ensures the connection between the primary shaft (of the wind turbine) and the secondary shaft (of the generator);

– The generator shaft or secondary shaft drives the electric generator. It is equipped with a mechanical disc brake (security device), which limits the speed of rotation in case of a violent wind;

– The electric generator ensures the production of electricity. Synchronous alternating current generators can be of classic construction or with permanent magnets, operating at fixed or variable speed.

2.1. Unconventional PCP pump action (Progressive Cavity Pumps)

Progressive cavity pumping (PCP) systems derive from the positive displacement pump, which evolved from the gear pump concept first developed by Rene Moineau in the late 1920s. Although these pumps are most commonly called cavity pumps progressive, they can also be found under the name of screw pumps or Moineau pumps [2].

Progressive cavity pumps (figure 4) were originally widely used as fluid transfer pumps in a wide range of industrial and manufacturing applications, with some attempts made to use them for surface transfer of field fluids oil tankers. However, it was not until the development of synthetic elastomers and adhesives in the late 1940s that progressive cavity pumps could be used effectively in applications involving petroleum-based fluids. The basic configuration of the surface actuated PCP system illustrated in (figure 2) is the most common, although both electric and hydraulic downhole actuation systems and various other hybrid PCP systems are also available. The cavitation pump for wells is a volumetric pump, it is composed of two parts: a helical steel "*rotor*" and a "*stator*" composed of a tubular steel casing, with an elastomer sleeve properly adapted to the configuration of the rotor. The stator is usually placed in the well, at the bottom of the extraction column, while the rotor is connected to the bottom of the rods.

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The results measurements of solar and wind water pumping system From the measurement of solar panel voltage changes to changes in solar radiation can be shown in (figure 3). In this figure, indicated that the peak of the solar radiation that is around 13:00 and the voltage at a minimum unreadable solar panel that is around 19:00.

Results testing the performance of the solar panel system as the water pump drive generates average voltage coming out of the solar volts [6], which is used as a pump drive on agricultural land with the stored battery power will be exhausted at 22:00 (figure 5).

The rotation of the rods via a surface drive system causes the rotor to rotate within the fixed stator, creating the pumping action necessary to bring the fluids to the surface [7].

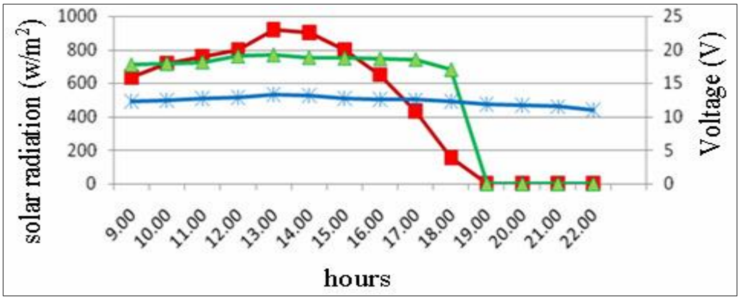

Figure 3 – Distribution intensity of the sun, solar and battery power voltage.

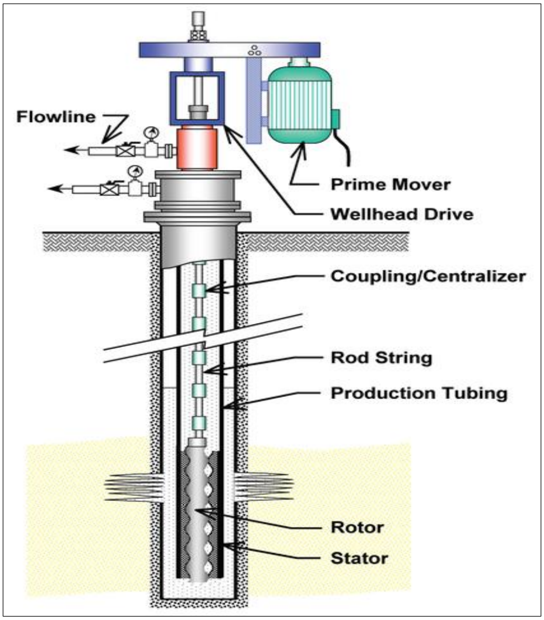

Figure 4 – Configuratio of a typical Progressive Cavity Pump (PCP) system

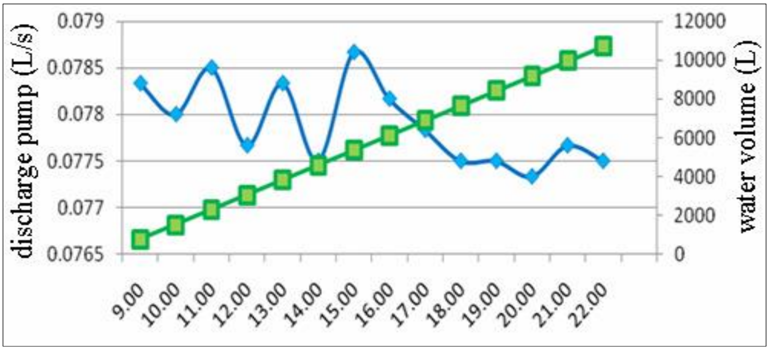

Figure 5 – Pumps discharge and the volume of water that can be at capacity.

PCP systems have several unique design features and operating characteristics that favor their selection for many applications:

– high energy efficiency system, usually between 55 and 75 %;

– the ability to transport products with high concentrations of sand or other solid products.

– the ability to tolerate high percentages of free gas;

– there are no valves or piston parts that can block or wear;

– good resistance to abrasion;

– low internal shear rates;

– relatively low electricity consumption, having a continuous power demand;

– relatively simple installation and operation;

– maintenance is generally easy;

– low-profile surface equipment;

– the surface noise level is low.

However PCP systems also have some limitations and special considerations:

– limited production rates (maximum 800 m^3/d) for large diameter pumps, much lower for small diameter pumps);

– limited lifting capacity (maximum 3000 m). Note that larger pumps have a much lower lifting capacity;

– the ability to withstand temperature is limited (routine use is at 100 °C, potential use is at 180 °C with special elastomers);

– sensitivity to the fluid environment (the stator elastomer can swell or deteriorate when exposed to certain fluids, including well treatment fluids);

– they may have a reduced volumetric efficiency in wells that produce substantial quantities of natural gas;

– the drive rod may be susceptible to material fatigue;

– the stator may suffer permanent damage, if the pump operates on dry land even for short periods;

– rod and tubing wear can be problematic in directional and horizontal wells;

– most systems require the tube to be removed to replace the pump;

– vibration problems may occur in high speed applications (mitigation may require use of tube anchors and rod stabilization);

– removal of paraffin can be a problem in rough waxy applications (rod prevents scrapers for efficient wax removal).

– lack of experience in system design, installation and operation, especially in some areas.

Many of these limitations continue to change or be mitigated over time with the development of new products and improvements in design materials and equipment [3].

2.2. Cavitation pump lift system

The basic components of the system include the downhole pump, the pump rods and production tubing strings, and the surface drive equipment. However, a PCP installation may also include various equipment and accessories such as gas separators, rod guide rollers, tubing, stringers and surface equipment controls. The following sections describe the various components of a PCP installation.

2.3. PC pump from the borehole

Cavitation pumps can be single rotor, helical gear pumps all within the category of positive displacement pumps. The rotor represents the "*internal stage*" and the stator is also called the "*external stage*" of the pump. The stator always has more of a "*tooth*" or "*lobe*" than the rotor. Cavitation pumps currently on the market fall into two different categories, depending on their geometric design: single-lobe or multi-lobe. Currently, the vast majority (> 97 %) of wellbore cavitation pumps are single-lobe and are therefore the most efficient option to be powered by a hybrid system.

The geometric design of a single-lobe cavitation pump is illustrated in (figure 6). The longitudinal cross-section in (figure 6) features the unique helical shape of the rotor and the corresponding helical geometry of the stator. Note that the length of the stator pitch (Ls) is twice the length of the rotor pitch in single-lobe pumps. With the rotor and stator mating in a single-lobe CP pump, two parallel, helical cavities (180° to each other and one rotor pitch out of phase) are formed that revolve around the outside of the rotor along the length of the pump, each cavity having a length equal to the stator pitch length.

In the single-lobe pump, the cross-section of the rotor is circular (with a small diameter d), while the cavity in the stator has a semi-elliptical geometry. Another important geometric parameter is the eccentricity of the pump (e), which is equal to the distance between the axes of the major and minor diameters of the rotor. The distance between the axis of the stator and the axis of the maximum diameter of the rotor is also equal to the eccentricity value. The rotor creates a seal with the stator elastomer on both sides of the semi-elliptical opening and a seal over the semi-circular stator opening at the positions corresponding to the ends of the longitudinal cavities. The liquid cavities are formed by the open areas left between the rotor and the stator at each cross-section. Figure 7 shows a sectional view of a single-lobe CP pump and the geometry of various rotors and stators in several pump designs.

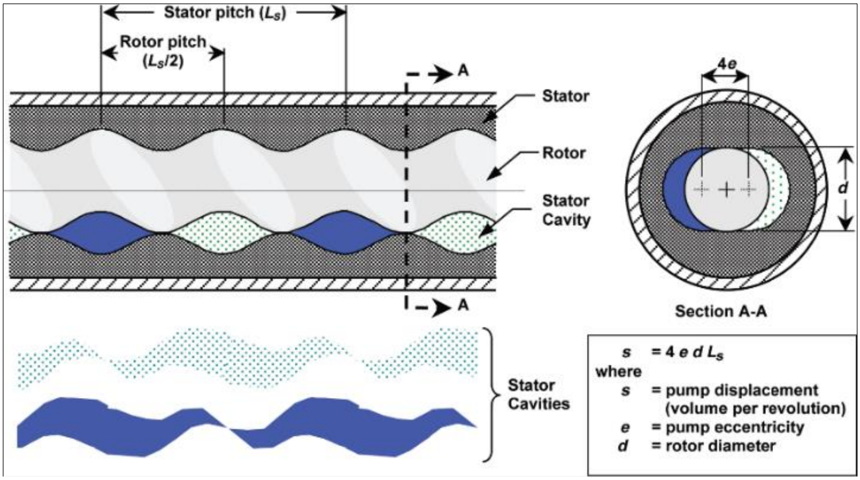

Figure 6 – Geometric characteristics of a pump with progressive cavities with a single lobe.

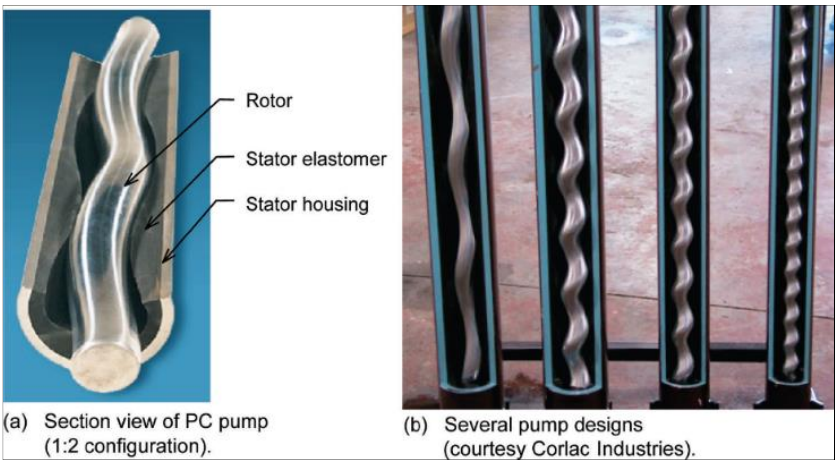

Figure 7 – Sections of toros/stators in different models of progressive cavity pumps.

During extraction, the rotor moves back and forth across the stator opening while being rotated within the stationary stator. This occurs due to a combination of two movements: counterclockwise rotation of the rotor around its own axis and counter-clockwise eccentric rotation of the rotor around the neutral axis of the stator. Figure 8 illustrates the movement of the rotor inside the stator opening for a complete rotation [5].

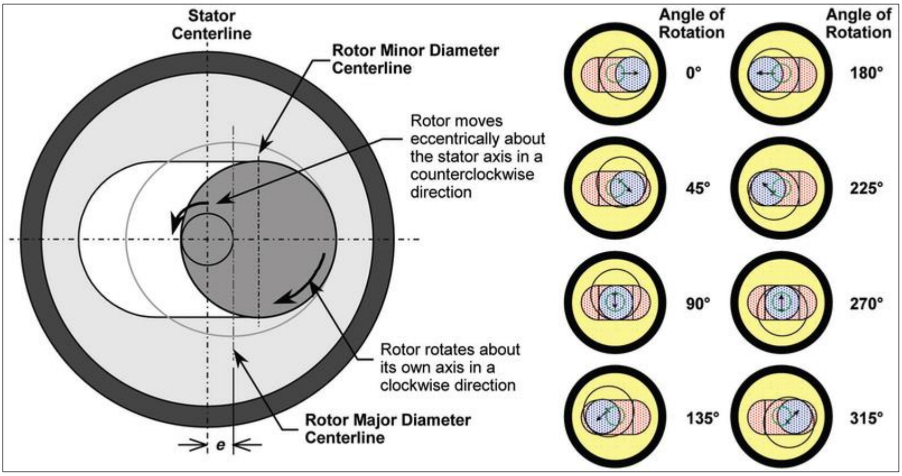

Figure 8 – Rotor movement in single – lobe pumps.

3. Renewable energy supply

The 10kW single-phase hybrid system combines solar photovoltaic technology by obtaining electrical energy with the help of electrical photovoltaic panels and wind turbines, which produce energy with the help of the wind. These hybrid single-phase photovoltaic and wind systems provide stable electricity supply to all consumers, despite the weather conditions. The advantage of hybrid systems is that the photovoltaic panels work in parallel with the wind turbines, and the unconsumed electricity is stored in the system's solar accumulators. The system is durable and efficient, the initial investment amortizing in a short time. The 10kW single-phase hybrid system ensures 40 kWh annual average daily production from the electric photovoltaic panels, the accumulators can store 21.6 kWh, and the wind turbine can produce 600 kWh in case of 11 m/s wind [8].

Powering the pump with progressive cavitation from renewable sources will be achieved as follows: the photovoltaic generator and the wind generator – convert the energy received from the sun as well as the wind energy into direct current electricity, using the photovoltaic effect and the rotational movement of the turbine blades.

The generators will generate voltage and direct current. However, the cavitation pump drive motor requires alternating current. The photovoltaic system must therefore contain a d. c. converter. – a. c., i.e. an inverter. In addition to the conversion function, an inverter performs many other functions, thus being the most intelligent component of a Hybrid System. Charge controllers will store the energy generated by photovoltaics and wind using electric batteries to extend their life (by avoiding excessive discharge or overcharging) [9].

The power of the direct voltage "generated by the generator in many situations does not correspond to that required for the proper functioning of the consumer". In order to "transform" the direct voltage to an appropriate level, electronic blocks called DC converters are used. They are also found as separate blocks, but most of the time they appear in the composition of inverters or some blocks for adapting the load to the generator (called M.P.P.T. – Maximum Power Point Tracker). If the hybrid system is connected to the national electricity grid, and the electricity production is higher than what is needed to operate the cavitation pump motor and the accumulator batteries are charged, it will inject the surplus energy into the grid that can be used at a later date, thanks to the bidirectional counter. If connecting to the national grid is not possible, alternative energy supply becomes the most cost-effective solution. To create the hybrid system presented above, it is not necessary to purchase the 10 kW ON GRID inverter, but for safety (in case of hybrid system failure), a diesel generator with a power of 10 kW can be installed [4].

4. Conclusions

The sun is undoubtedly a vast source of energy. In a single year, it sends to Earth 20,000 times the energy needed for the entire population of the globe. In just three days, the earth receives from the sun the equivalent of the energy existing in fossil fuel reserves. Solar energy represents one of the potential future energy sources, used either for the definitive replacement of conventional energy sources such as: coal, oil, natural gas, etc., or for its use as an alternative to the use of conventional energy sources, especially during summers, the second use being at the moment the most widespread use throughout the world.

Benefits:

– does not pollute the environment, being a source of clean energy;
– the energy source on which the entire technology is based is free;

– the possibility of providing electricity in isolated locations;

– they can be extended in case of the appearance of additional electrical consumers.

– the average duration of use of panels and wind turbines is 20 – 25 years.

Disadvantages:

– the high cost of the investment, the location of the hybrid system on incorrect geographical axes determines the decrease in the efficiency of the installation and the danger of the destruction of the panels, caused by bad weather; the risks in case of calamities increase – the panels and turbines being exposed to the weather.

Depending on the energy supplied, solar panels can be divided into photovoltaic panels (which generate electrical energy) and thermal solar panels (which transform light energy into thermal energy). Solar panels are one of the most popular sources of alternative energy used for private and industrial electrical systems.

Small wind turbines play an important role in off-grid projects in windy locations where they provide economical supply energy, since alternative solutions such as diesel generators have a high fuel cost when used continuously for power supply. This can also apply to grid-connected installations, despite the fact that their production price per kWh is usually higher than that of large wind turbines.

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