OPERATING THE OIL PRODUCTION FACILITY WITH SOLAR PANELS AND WIND GENERATORS

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Abstract: *In this paper we present an analysis of theoretical concepts very common nowadays, photovoltaic power generators and wind turbines. In addition, we propose an application, a hybrid generator (photovoltaic-wind) to power a progressive cavity pump used for the extraction of petroleum.*
Key words: *photovoltaic systems; wind turbines; power; progressive cavity pump;*

1. INTRODUCTION

Sun is undoubtedly a vast source of energy. In a single year, it sends to Earth 20,000 times the energy needed by the entire world population. In just three days, the earth receives from the sun enough energy to equal all existing fossil fuel reserves. Solar energy is one of the potential future energy sources to be used permanently replacing conventional energy sources such as coal, oil, natural gas, etc.; however, it can be used today as an alternative to the conventional sources of energy, especially during summer. The second use is currently the most widespread use around the world. Perhaps the most obvious advantage to using the solar energy is that it does not produce environmental pollution, so it is a clean energy source; another advantage of solar energy is that the energy source used is for free.

A photovoltaic system (SFV) "converts solar energy directly into electrical energy based on the photovoltaic effect, and brings it to the electrical parameters required by the consumer", [1].

The solar cells can be classified according to several criteria. The most commonly used criterion is the one that classifies cells after the thickness of the material. Here we can make the difference between thick cells and thin cells.

Another criterion is the kind of material used, for example, combinations of semiconductor CdTe, GaAs or CuInSe but the most often used is silicon.

Silicon cells

• Thick layer

- Mono crystalline cells (c-Si) with high efficiency - in serial production can reach to over 20% power efficiency; the manufacturing technique is very well developed. However, the manufacturing process is energy intensive, which has a negative influence on the period of recovery (the time needed for the equivalent energy consumed in the manufacturing process to become equal to the amount of energy generated).

- multicrystalline Cells (mc-Si) - the serial production has already achieved an energy efficiency of over 16%, relatively low energy use in the manufacturing process, and, so far, the best price – performance ratio.

• Thin layer

- Amorphous silicon solar Cells (a-Si) – represents the largest segment of the market with thin film cells; the energy efficiency of the modules is from 5 to 7%; there are no bottlenecks in supply even at a production of Terra Watts.

- Crystalline silicon cells, e.g. microcrystals (μc-Si)

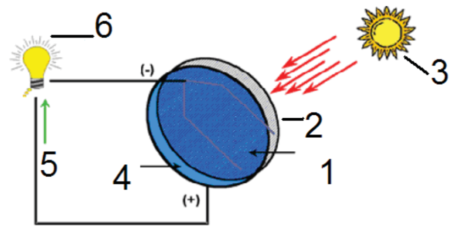

Fig. 1. *The working principle of photovoltaic cells (source: solar.promacht.ro), [2]*

1 - silicone coating (type N)
2 - photovoltaic cell
3 - sunlight
4 - silicone coating (P)
5 - DC Flow
6 - electric charger

Semiconductors based on III-V group elements

• GaAs cells – high efficiency, very stable at temperature changes,

Semiconductors based on II-VI group elements

• Cells with CdTe – use a very efficient CBD technology (deposition of thin layers on a large surface, with controlled pH environment, temperature and concentration of reagent)

• CIS, CIGS Cells - CIS stands for Copper-Indium-Diselenide produced in a pilot plant, or Copper-Indium Disulfide, and CIGS Copper-Indium-Gallium-Diselenide produced in pilot plant.

Solar cells based on organic compounds - organic chemistry based technology provides compounds

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that can allow cheaper manufacture of solar cells. However, they have an impediment that these cells have a low efficiency and a reduced lifetime (max. 5000h).

Pigment cells **-** also known as Grätzel cells, natural pigments used for converting light into electricity; a procedure that is based on the effect of photosynthesis. Usually they are purple.

Semiconductor electrolyte cells **-** cells are very easy to manufacture, but their power and safety of use are limited [1].

Cells based on polymers **-** now in the research stage only.

The total thickness of the photovoltaic cells is approx. 0.3 mm, and its layer thickness is approx. 0.002mm. Usually, above the negative electrode of the photovoltaic cell, there is an anti-reflection coating, aiming to prevent the reflection of solar radiation incident on the cell surface so that "a higher amount of energy can be transferred to the valence electrons of the two semiconductor layers." [8] Photovoltaic cells have as the most usual size 10x10cm but, lately, 15x15cm cells have been used.

Besides the photovoltaic generator-cell, a module or photovoltaic panel for efficient use of electricity and other components are necessary.

For example, to compensate for the dependence of power generation on the solar radiation, in most cases electrical energy storage means are required or a battery.

Its correct functioning implies a load control block. Adapting the PV generator to the consumer's electrical parameters requires either a DC-DC converter, or a DC-AC one, or both. In some situations the "photovoltaic generator is coupled with alternative resources."

All of these components, working together, constitute a system called photovoltaic system.

PV systems fall into two main categories:

• autonomous systems ("stand-alone"), which supply consumers not connected to the public network adapter. These systems are used in areas without electricity.

In principle, "the energy produced by the solar panels is stored in batteries" and the system contains an inverter (DC Converter - AC), 220V home users (Fig. 2).

• Nonautonomous systems, or connected to the public network adapter ("Grid - connected") (Fig. 3).

These systems are used in areas with electricity. In principle, the energy produced by the solar panels is fed into the national grid and simultaneously used for household applications.

How the system is designed may affect its life. The design process "must be carefully reviewed and must take into account all aspects, in order to get the best features" based on available resources and taking into account potential losses from the system to maximize profitability. This can be achieved in various ways, but choosing the best components (a quality inverter can increase production by 2% using the same materials) and the choice of appropriate installation technology are crucial [3].

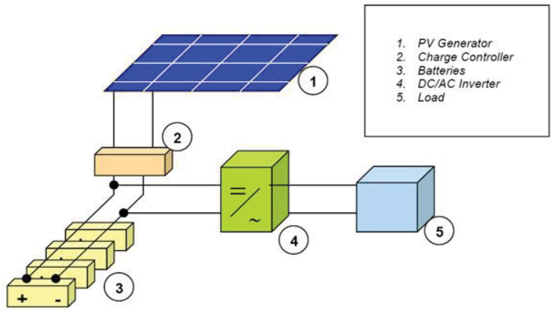

Fig. 2. *A "stand-alone" photovoltaic system [11]*

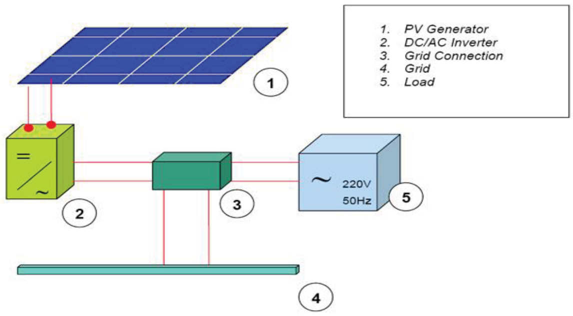

Fig. 3. *A "grid-connected" Photovoltaic system.[11]*

2. ELECTRICITY WITH PHOTOVOLTAIC SYSTEM

Applicability. Power produced by photovoltaic systems is useful in most applications including for motors, pumps, electrical equipment and lighting. The use of photovoltaic systems is not recommended the in water heating systems or for cooking (microwave, toasters can be used due to reduced working time). For these, applications dedicated solar systems are in use (heating habitat with solar systems) (Fig. 4).

Shading. Unlike solar heating systems, shading in the case of photovoltaic solar panels can have an important effect in the efficiency of the system. Some solar modules provide partial protection to shading by using a diode between each cell.

Angle of installation for solar panels. Because the angle of the sun in the sky varies according to the season it is useful to bring corrections to panel position: + 15 degrees in winter and - 15 degrees in summer.

Choosing voltage is determined by the size of the system. For small and medium systems where most consumers are DC (Fig. 4) or, through a converter, some consumers are AC (alternating current) the choice is simple - 12 V. Moreover, solar modules and consumers cannot be positioned at a distance one the other due to losses. 24 V systems are for medium and large applications due to the lower losses and to the use of more efficient alternating current (AC) converters. With the increase of efficiency for utilities with alternating current (AC) systems of 24 V and 48 V have several advantages in large applications (connecting batteries).

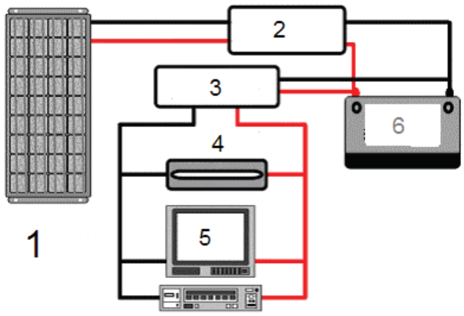

Fig. 4. *Solar system for independent consumer using DC, [13]*

1 - photovoltaics
2 - load control
3 - Disconnect
4 - fluorescent light (CC)
5 - TV, radio
6 - deep cycle

The controller is the part that determines when the battery is fully charged without allowing overloading; it prevents leakage of energy from the solar cell battery overnight, reduces battery deterioration by a total discharge, and may show the state of the system and offer short circuit protection.

Converter. The core component of an environmental system that converts low voltage DC current into high voltage alternating current (AC). The main feature is the efficiency of the device.

3. WIND TURBINES

Wind energy is the result of the activity of the Sun and is formed due to uneven heating of the Earth's surface. The movement of air masses is formed due to different temperatures of two points on the Globe, with the direction from the hot to the cold point.

Wind as a primary energy source costs nothing. It can also be used decentralized – it is a good alternative for small localities distant from traditional sources.

Starting with the beginning of human civilization, wind energy was used in sailing. It is assumed that the ancient Egyptians went under sail far back as 5,000 years ago. Around 700, in Afghanistan vertical rotation axis wind machines were used for grinding the grains. Well-known wind turbines (tower mills with propellers connected to them) ensured the functioning of irrigation systems on the island of Crete in the Mediterranean. Mills for grinding grain, which run on wind, are one of the greatest performances of Middle Ages. In the 14th century, the Dutch improved the windmills model which was spread across the Middle East and began the widespread use of wind turbines for grinding beans.

In 1854, in the US, a water pump that operated on wind energy was developed. The construction of this pump model resembled windmills, but it had more blades (arms) and a wind vane to determine wind direction [5].

By 1940, in the US, over 6 million installations of this type were used for pumping water and producing electricity. It is considered a prerequisite for conquering the Wild West because of the potential water supply for livestock farms. But mid-twentieth century brings to an end the widespread use of wind energy, exchanging it for its modern counterpart energy source - oil.

The wind energy interest reappeared after several oil crises experienced by mankind for decades. This happened in the early 70s, due to the rapid increase in oil prices when the US had adopted several programs to encourage the revaluation of wind energy. In California, at the end of 1984, 8469 wind turbines were already in operation. The total capacity of these units was approximately 550 MW. They were built in places with strong winds, grouped into so-called wind farms.

Wind turbines for producing electricity can be used individually or in groups, called wind farms. Wind farms, which are now fully automated, ensure, for example, 1% of California's electricity needs, i.e. 280 000 homes. However, wind turbines had some problems: large changes in wind speed causing variations in electric current generation and sometimes damaging the transmission systems; after a while, rotor blades collected foreign substances, dust etc., which reduced their efficiency [4].

To measure wind speed and temperature a Data Logger can be used. It is an electronic device that records data over time and, correlating with the location of sensors and transducers in a given location, it processes the data using a programmable logic microprocessor and displays information on the display screen or transmits it to a PC.

The Data Logger used for acquisition of slowly varying data, with a maximum acquisition speed of 1Hz are not considered real-time data acquisition devices. Data Logger processed data is stored on a flash memory or EEPROM. The main applications of this system are recording wind speed, temperature and humidity.

The main blocks and Data Logger system logic for measuring wind speed and data processing using the Hyper Ware software programming are shown in Figure 5.

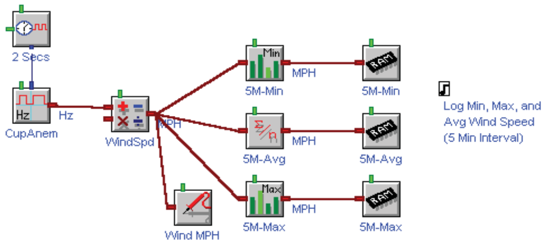

Fig. 5. *Wind speed measurement*

A wind system, figure 6, in terms of energy, converts kinetic energy of wind into electricity.

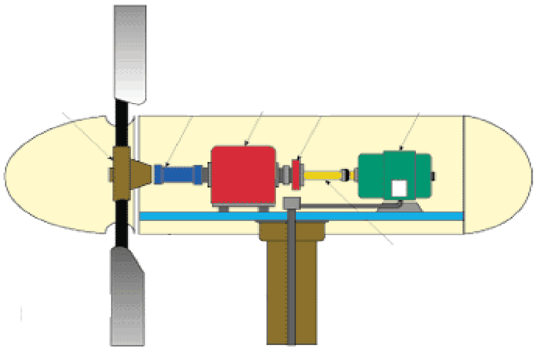

Fig. 6. *Wind System Components*

4. UNCONVENTIONAL POWERING WITH SOLAR PANNELS AND WIND GENERATOR FOR A PCP OIL EXTRACTION SYSTEM

Sizing a renewable source of energy to power 10 kW

One of the most common applications of alternative energy is now the power supply for a holiday home or cottage, located in an area without access to the public, but in view of the developments in technology, hybrid systems may be successfully used in industrial fields. To power a progressive cavity pump we can decide for producing power using photovoltaic panels or wind generators. Their combined use is always possible and recommended due to the purpose of use and relatively high power needed.

To provide all these consumers with electricity, a solar panels system must produce all the electricity required. These consumers need about 8 KWh per day for 7 days a week or we can consider an average consumption of 270 kWh / month.

The system has an autonomy of two days, which means it can provide the energy needed for 2 days even without any application of energy from the photovoltaic solar panels and the wind turbine.

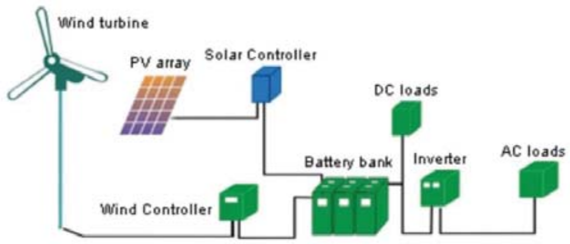

Fig. 7. *The solar-wind hybrid system*

For this application we will need the following components:

- photovoltaic solar panels;
- a wind turbine;
- group of batteries (rechargeable batteries) to 12 V;
- battery charge regulator;
- inverter DC (12V) - AC (220V);
- energy saving lamps DC;
- equipment and connectors for assemblies.

To cover the consumption we will need:

- 84 x 250W photovoltaic panels (21 KW installed capacity);
- 1 x 10 KW Wind Turbine KIT;
- Charge 4 x Vario Track 80A Controllers;
- 3 x XTM 3500-48V inverter Studer;
- 1 x RCC-02 communication interface;
- 24 x Hoppecke 12V deep cycle battery with 4700Ah;
- 1 x 10kW SMA inverter On grid

Where the electricity grid is near the extraction well, a hybrid system can be connected to the network and, once batteries will be charged at 100%, they will inject the excess of energy into the national grid; this energy could be used at a later date due to a bidirectional meter.

If the national electricity network is at a greater distance of 300-400 m from the well location, alternative energy supply is the most cost-efficient solution. To achieve a hybrid system, shown above, it is not necessary to purchase an ON GRID 10 KW inverter but, for safety (in case of failure of the hybrid system), a diesel generator with a capacity of 10 KW can be installed.

5. OPERATING THE PCP PUMP WITH UNCONVENTIONAL RENEWABLE ENERGY

The basic configuration of the surface driven PCP system illustrated in Figure 8 is the most common, although the downhole pumps are both hydraulic, electric and hybrid CFP, various other systems are also available [10]. The PCP well pump is a positive displacement pump composed of two parts: a steel "impeller" screw and a "stator" composed of rugged steel cylinder with a sleeve of elastomer adapted properly 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 rod. Rotation of the rod by means of a drive system at the surface causes the rotor to rotate within a fixed stator, creating the pumping action required to bring fluids to the surface.

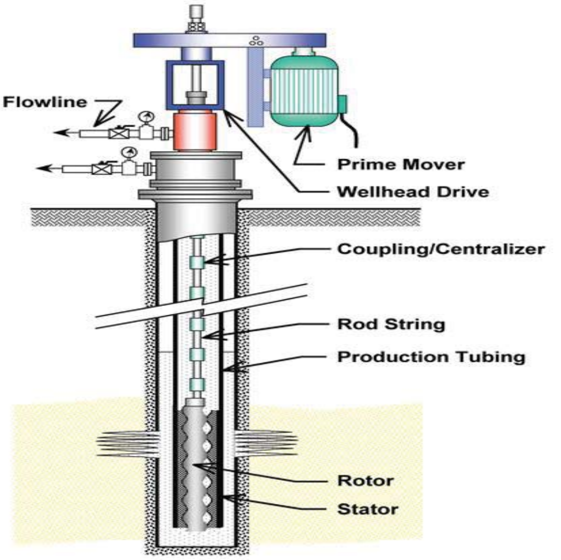

Fig. 8 *Typical configuration of a system of progressive cavity pumping (PCP)*

PC downhole pump

Cavity pumps can be single-rotor helical gear pumps all in the category of positive displacement pumps. The rotor is the "internal gear" and the stator is called the "external step" of the pump. The stator has always an extra "tooth" or "lobe" than the rotor. Cavity pumps that are found currently on the market fall into two different categories, according to their geometric design: single lobe pumps and multilobe pumps. Currently, the vast majority (that is, somewhere in> 97%) of cavity pumps that are used in drilling wells are with a single lobe and, therefore, they are the most effective solution to be powered by a hybrid system; [7].

The geometric cavitations pump with a single lobe is illustrated in Fig. 9. In fig. 10, we presented the single helical shape of the rotor and the helical geometry corresponding to the stator. Note that the stator step length (Ls) is twice the rotor step length for pumps with a single lobe. With the pairing of the rotor and the stator in a CP pump with a single lobe, two parallel cavities are formed (at 180 ° with respect to one another with an out of phase rotor step) which rotates around the outside of the rotor along the length of the pump, each cavity having a length equal to the stator step length. Note that the parallel recesses are offset lengthwise with the end of a cavity on one side of the rotor corresponding to the maximum cross section on the opposite side of the cavity, [8].

In a single lobe pump, the rotor is of circular cross-section (with a small diameter, d), while the stator cavity has a semi-elliptical geometry. Another important parameter is the geometric eccentricity of the pump (s) which is equal to the distance between the axes of the major and minor diameters of the rotor. The distance between the stator axis and the rotor axis of maximum diameter is also equal to the eccentricity.

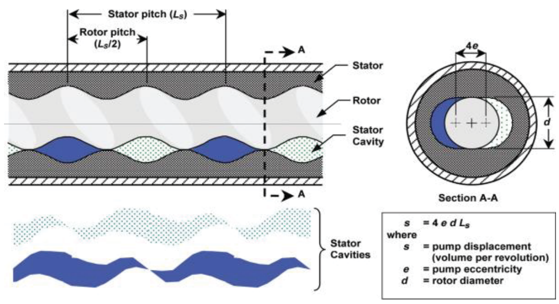

Fig. 9. *The geometrical characteristics of a pump with hp with a single lobe, [9], [13].*

The rotor creates a seal with the stator elastomer on both sides of the opening, a half-elliptic and a semi-circular stator seal over the opening ends of the corresponding longitudinal cavities. Fluid cavities are formed by remaining open areas between the rotor and stator, each cross section. Fig. 10 shows a sectional view of a single lobe pump with CP rotors and stators and different geometry in several models of pumps.

Renewable energy supply

The 10KW monophase hybrid system combines the photovoltaic solar technology with the obtaining of electricity using photovoltaic electric panels and wind turbines, producing energy from wind. These single-phase PV and wind hybrid systems offer stable electricity supply to all consumers, despite the weather conditions. The advantage of hybrid systems is that photovoltaic panels operate in parallel with wind and consumed electricity is stored in the solar system batteries. The system is sustainable and efficient the initial investment being covered in a short time.

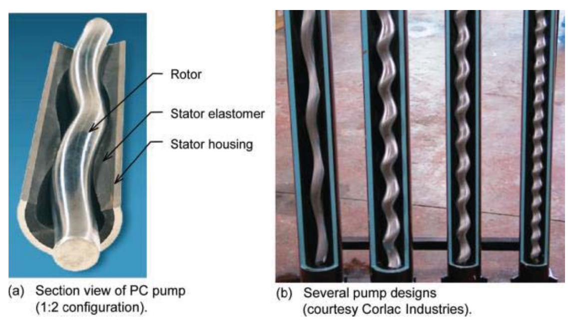

Fig. 10. *Sections rotor / stators from different pump models*

The 10KW monophase hybrid system provides a 40 kWh average daily production each year from solar panels; electric batteries can store 21.6 kWh and wind can produce 600Wh when wind speed is 11 m/s.

The powering of progressive cavity pumps from renewable sources will be achieved as follows:

The Photovoltaic generator and the windmill - convert the energy received from the sun and wind in DC electricity using the photovoltaic effect and rotational movement of the turbine blades.

The generators will produce voltage and DC. However, the motor of the cavity pump requires AC power. The photovoltaic system must therefore contain a converter DC-AC i.e. an inverter. Besides the converting function, an inverter performs many other functions being the most intelligent component of a hybrid system.

The charging regulators (or controllers) will store the energy generated using photovoltaic cells and wind in batteries to prolong their life (by avoiding excessive discharge or overcharge).

The voltage of the DC electricity "produced by the generator in many cases does not correspond to the necessary voltage for proper functioning of the consumer." To "transform" continuous voltage to an appropriate level, we use electronic blocks called CC converters. They can be found as distinct blocks, but more often appear in the composition of inverters or of other blocks which adjust the load to the generator (called MPPT - Maximum Power Point Tracker).

If the hybrid system is connected to the national electricity grid and electricity production is higher than necessary for the function of the cavity pump engine and the batteries are charged, the system will inject the excess of energy into the national grid and this energy could be used at a later date due to a bidirectional meter [11].

If connecting to the national grid is not possible, alternative energy supply is the most cost-efficient solution. To achieve the hybrid system described above, it is not necessary to purchase an ON GRID 10 KW inverter, but, for safety (in case of failure of the hybrid system [12]) a diesel generator with a capacity of 10 KW can be installed.

6. CONCLUSIONS

Depending on the energy provided, solar panels can be divided into photovoltaic panels that generate energy and solar thermal panels, which convert light energy into thermal energy. Solar panels are one of the most popular alternative energy sources used to power private and industrial consumers. Solar technologies use the sun's energy to produce heat, light, hot water and even air conditioning for residential and industrial areas.

Small wind turbines play an important role in off-grid projects in locations where winds ensure enough energy supply, since alternatives such as diesel generators have a high cost of fuel when used as a continuous power supply. This is also applicable to installations connected to the power grid, despite the fact that their production price per kWh is usually higher than in the case of large wind turbines.

Photovoltaic solar panels and wind generators (hybrid systems) also produce electricity. The advantages of using solar panels and wind generators is represented primarily by the possibility of providing electricity in remote locations without access to the main electricity supply (the national grid). Such a system is easy to install, requires no special knowledge in the field of energy and the maintenance for the panels is easy (it only requires cleaning the impurities that attach to their surface).

The average use of panels and wind turbines is 20-25 years, the only part that needs more attention and whose lifespan is shorter for the isolated systems are the batteries.

Another considerable advantage of these systems is that they can expand in case of additional electrical consumers. Disadvantages include: high cost of investment, geographical location on latitudes which lower the efficiency of the systems and the danger of destruction for panels because of weathering; increase disaster risks - panels and turbines are exposed to weather conditions.

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