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## Renewable Sources of Energy in Poland - photovoltaics

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Summary: Photovoltaics is used for producing the electric energy from the solar radiation. These installations are becoming more and more popular. Their main advantage is the possibility of being mounted at any place without the significant interference into the landscape. They can be used by household and/or the produced energy can be sold. Due to the obligation concerning the provision of 15.5% of energy coming from the renewable sources of energy by Poland in 2020, the solar energy can have a significant impact on the shape and work of national distribution network.

Key words: photovoltaics, renewable sources of energy

### Introduction

Photovoltaics is the branch of science dealing with the conversion of solar radiation energy into the electric energy by the application of photovoltaic cells (Kryszk & Kurowska 2014). Broadly, it concerns the production and distribution of photovoltaic panels, installation mounting, training, promotion of renewable sources of energy. Photovoltaics is one of the most common forms of electric energy production. It has the edge over the other renewable energy sources because it can be used almost everywhere. Photovoltaic installations are more and more popular in Europe. Every year, the collective power of new PV installations mounted on the roofs of commercial and residential buildings, as well as on the ground, is increasing

The photovoltaic cells can be applied in three market segments:

- PV micro installations up to 10 kW installed on the residential buildings,
- small and medium systems (10–100 kW) installed on the industrial buildings,
- large ground systems over 100 kW (Szczerbowski 2015).

## **History**

The voltaic effect was observed for the first time by French physicist, Alexandre Edmond Becquerel, in 1839. He was conducting the experiments concerning the conductivity of electrolyte and noticed that in the periphery of two lit electrodes (Cl – Ag) immersed in the electrolyte, the electric current intensity was increasing when the electrodes were lit. However, he could not explain that. In 1905, Albert Einstein using the quantum theory by Max Planck described the complete photovoltaic effect, which resulted in obtaining the Noble Prize. Then, Russel Ohl constructed in 1941 the first photovoltaic cell with the p-n junction. The significant influence on the production of silicone photovoltaic cells had the production method of high-purity silicone crystals elaborated at the turn of the 40s and 50s by Jan Czochralski – Polish chemist. The photovoltaic cells were used for the first time to power the earth satellite. In 1958, Vanguard I, the earth satellite, was equipped with the photovoltaic cells. The photovoltaic modules consisting of 6 cells were installed in it which provided 5 W electric power. The demand of energy sources of little mass and high reliability for the space appliance was the driver of photovoltaic technology development in the initial period. Only in the 60s, the technological advance enabled to use the photovoltaic cells in the commercial applications. The constant development of photovoltaics enables to achieve higher efficiency and lower and lower investment costs, which results in the increasing number of installed photovoltaic systems (Biłgorajski 2015).

## **Pros and cons of photovoltaics**

The main advantage of photovoltaics is the fact that photoelectric conversion occurring in the photovoltaic cells is currently one of the most perspective ways of using the solar radiation energy. Photovoltaics does not emit any harmful substances, noise and carbon dioxide. The PV systems are fixed, resistant for atmospheric conditions and practically headless. Lack of moveable components – (lack of replacement parts). The solar power plants are easily mounted and are able to work even for 30 years. The photovoltaic panels are completely recyclable.

The development of big photovoltaic farms in Poland is enhanced by their neutral character for this type of investment. They have significantly less impact on the landscape and their sources are being completed during the natural processes which enable to treat them as non-finishing. Photovoltaics, in comparison to the wind power plants and biogas plants, is much easier accepted by the society. It is mostly used on the roofs of buildings, balconies, signs, street lamps etc. It is a new small element which appears on the existing object (Kryszk & Kurowska 2014).

The disadvantage of the photovoltaic panels is the energy consumption of the production process and using the toxic elements then i.e. cadmium, arsenic, selenium, tellurium (Krzywda & Jurasz 2014). Due to the geographical location, photovoltaics will never be the basic source of electric energy. It can play the role of diffused source of energy used mainly on spot, limiting the transmission wastes. This situation may change though if the significant parameters of available electric energy storages appear. The basic problem in photovoltaics is the fact that the amount of solar radiation varies during the year, usually disproportionately to the energy needs of the occupied object (Sarniak 2015). The possible danger caused by the photovoltaic cells is the occurrence of short circuit which can cause the existence of electric arc. This arc generates very high temperatures which can cause fire. The other problem is the fact that during fire fighting action, in the place of PV system, the fire fighter may get electric shock while cutting the wires being under voltage (Szczerbowski 2015). There are still many challenges in front of the manufacturers of photovoltaic cells to remove the aforementioned production faults.

### Operation of photovoltaic panels

The photovoltaic cells can be made of such materials as: monocrystalline silicone, polycrystalline silicone, amorphous silicone and its alloys, silicone telluride and CISG – copper, indium, selenide and gallium mixtures.

The photovoltaic panels use the phenomenon of photovoltaic conversion. Sunlight is constantly absorbed by the cells of the absorbing material. Photons falling on the solid state p-n junction cause generating of direct current of voltage being dependant on cell's material and amperage - on the surface of cell. Photons cause the occurrence of pair of mediums having the opposite electric charges. Due to the fact that separated mediums are redundant mediums that have the so-called infinite lifetime and the voltage on p-n junction is constant, the medium on which the light falls works like stable electric cell. Then, current enters into the external circuit. All is covered with the protecting layer mainly made of glass whose maintenance is easy and does not require any specialist training course. The picture below presents the whole photovoltaic process occurring in the solar cells (Euro – Centrum 2013).

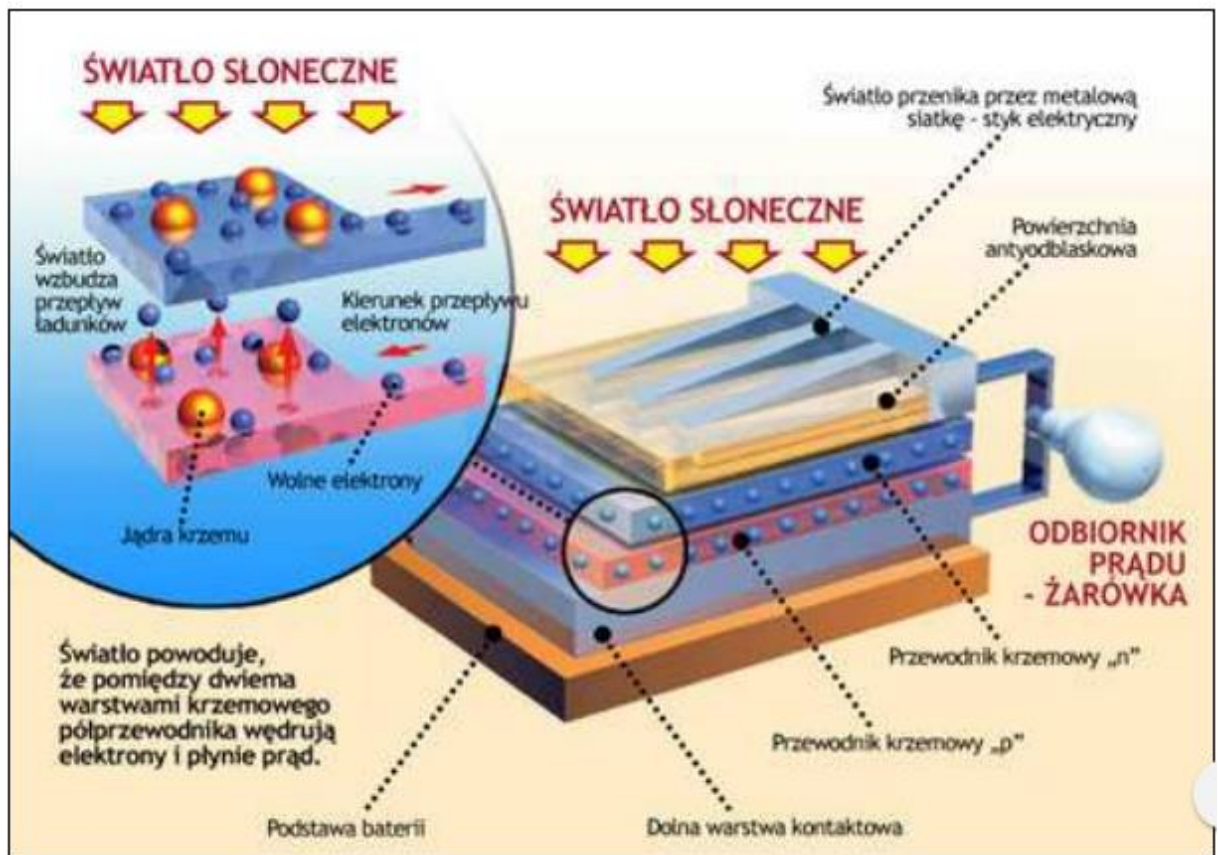


Fig. 1. Diagram of photovoltaic cell operation (source: <http://www.focus.pl>)

The photovoltaic system consists of the modules and photovoltaic panels as well as the components adjusting the produced direct current to the need of powered appliances. If the system is automatic or is created to power electric receivers at night, it is necessary to apply the appropriate storage system for energy produced during the day. It is usually energy accumulator. If the system powers the direct current appliances, the voltage adjuster is necessary. To power the free running appliances from the photovoltaic system, the power inverter is needed. The appropriate construction directing the modules and panels towards the sun and protecting against stealing is also required (Dołęga 2013).

Among the photovoltaic components, there are traditional PV panels as well as PIPV technology, i.e. the photovoltaics integrated with the building. This technology may include solar roof tiles, hydro-insulation foil, multicolour half-transparent panes or even the elevation elements. They are usually substitutes for the traditional building materials having their primary roles and additionally producing electricity (Głów & Kurz 2013).

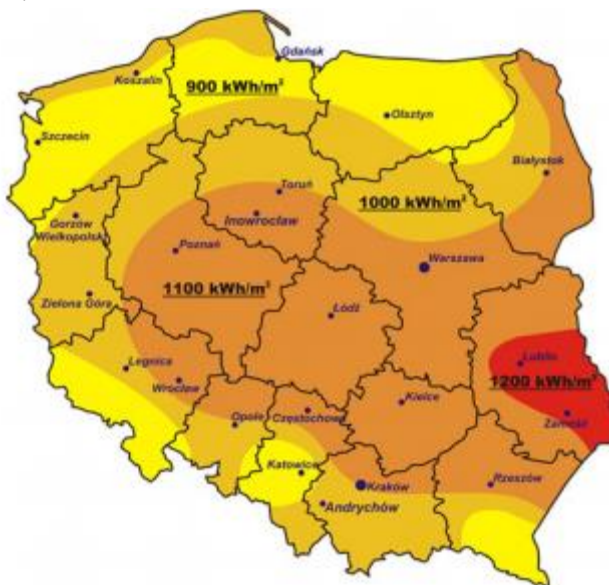
The kind of installation is determined by the final usage of energy produced by the photovoltaic panels. There are three basic types of installations: – connected with the utility grid (ON-GRID) – photovoltaic farms and procumbent installations, - not connected with the utility grid (OFF-GRID) – installations for own needs, - mixed systems (Kryszk & Kurowska 2014).

The research conducted in Beskid Żywiecki shows that the highest efficiency is observed in the installations equipped with the rotating modules, while the installations with the stationary modules have the efficiency of about 25% lower. The highest effectiveness of processing the solar energy into the electric energy is observed in the winter season, when it reaches up to 26%. The results obtained in the research station in Stryżaw are close to the results from Drezno region (Hilse & Kapała 2013).

### Usage

In Poland, solar collectors had the broadest usage being applied mainly for the needs of households and photovoltaics was applied in the road infrastructure. It is poorly widespread in Poland in reference to the European countries. In 2011, German photovoltaic installations had the power of 17 200 MW, while in Poland only 1,75 MW (Kryszk & Kurowska 2014).

The intensity of sunlight is dependent on the latitude, day time, season, atmospheric conditions etc. The resources of this energy are truly great. The photovoltaic installations can be applied in any place with solar radiation. However, the most appropriate is mounting them in the place with the great sunlight. Even a few minutes of absorption by only one hemisphere is enough for guaranteeing the annual demand of electric energy for the whole world (Olchowik 2011). In Poland, the distribution of solar radiation during the year is very uneven. Around 80% of total annual solar radiation is accumulated in the six months of spring and summer seasons. The least effective results are obtained in the winter season. The consequences of that are certain limitations in the possibility of using the stream of energy radiation.



Pic. 1. Map of solar energy intensity in Poland (source: [https://www.google.pl/search?q=Map+of+solar+energy+intensity+in+Poland&source=lnms&tbnm=isch&sa=X&ved=0ahUKewjZ4qyW65zWAhVQIIAKHfnkAuwQ\\_AUICigB&biw=1455&bih=677#imgrc=tmoVz9RO9wGB6M:](https://www.google.pl/search?q=Map+of+solar+energy+intensity+in+Poland&source=lnms&tbnm=isch&sa=X&ved=0ahUKewjZ4qyW65zWAhVQIIAKHfnkAuwQ_AUICigB&biw=1455&bih=677#imgrc=tmoVz9RO9wGB6M:))

Despite the differences in the intensity of solar energy in Poland, many natural persons as well as enterprises decide to invest in the photovoltaic panels. The combined installed power in the photovoltaic systems in Poland, in 2016, equalled approx. 199 MW. The power of PV installations, in accordance with the URE data, is 99 MW. The residuary 100 MW were installed in the micro stations connected with the network but not using the system of green certificates. Only in 2016, there were over 101MW of new power in photovoltaics, whereof approx. 73 MW were in micro installations. The total power installed in the renewable sources in Poland at the end of 2016 equalled over 8,5 GW. Comparing the condition presented by URE at the end of 2015 (71 MW) to the one in 2016 (99 MW), almost 40% of power increase was observed (almost 28 MW new installations appeared). The highest increase was observed in the first half of 2016 when the power of these installations increased of almost 21 MW.

The share of photovoltaics, despite the constant significant growth since 2014, is still infinitesimal and equals only 2.3% of power among the renewable energy sources and 0.5% of power being installed in the national energy system. Still, the dominating technology in the structure of power among the renewable energy sources is wind energy, but in the 2nd half of 2016 its development slowed down. The second source of renewable energy of significant share is biomass which overtook the water energy in 2013 concerning the power. In 2016, the power of PV installations approached the power of installations using biogas (234 MW).

All countries in the European Union had jointly 102.5 GW of the installed power in photovoltaics at the end of 2016. The share of Poland is infinitesimal and equalled only 0.1%. Concerning the installed power in PV in all EU countries, Poland would be on the 20th place (per 28 countries) (Instytut Energetyki Odnawialnej 2017).

### **Conclusion**

Due to the obligation concerning the provision of 15.5% of energy coming from the renewable sources of energy by Poland in 2020, the solar energy can have a significant impact on the shape and work of national distribution network. Therefore, the national politics shall promote this type of investments.

Mounting the photovoltaic system on the own house can bring many benefits i.e. lack of energy bills, possibility of selling the surplus, limitation of pollution being emitted to the atmosphere.

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