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MANAGEMENT OF A PHOTOVOLTAIC PARK

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Abstract: *Electricity comes from many sources, each with its own advantages and disadvantages. Availability and environmental impact are two of the most important criteria that will tilt the balance in favor of renewable energies, at the expense of fossil fuels, exhaustible and polluting resources for the environment. Green energy obtained from solar energy with the help of photovoltaic panels is topical and in great demand during this period. Whether it's household consumers, private companies or public authorities, everyone wants to get rid of energy bills. Technological advancement has substantially increased the efficiency of photovoltaic systems, from panels to inverters and equipment for management, reporting and remote action.*

Thus, the present work presents a management plan that includes the steps that an applicant must go through in the field of photovoltaic panels, from the idea to the commissioning of the photovoltaic park. Each stage is presented in detail. Also, the advantages and disadvantages of implementing a photovoltaic park are presented, becoming a guide that helps future applicants in this field.

It also presents possible questions that an applicant may ask, as well as the answers to them, so that if an applicant is unclear, this paper will provide him with the details he needs.

Keywords: *renewable sources, implementation plan, solutions, photovoltaic park, Gantt*

INTRODUCTION

In recent years, there has been an increasing emphasis on the importance of renewable energy. This type of energy is derived from natural sources, such as sunlight and wind, which are inexhaustible resources present everywhere. Therefore, it is a sustainable energy option with tremendous potential for the future.

Our planet receives energy from the sun in the form of heat and light. Some of the issues that society is currently facing can be resolved using the energy that the sun so generously provides.

Solar energy has been harnessed by humans for a long time, through the use of constantly evolving technologies. This has led to the emergence of more and more solar parks, so that the electricity used worldwide becomes green.

Solar energy is the most abundant of all energy resources and is even available on cloudy days.

Solar power plays an important role in the energy system, ranging from small household installations to large-scale projects.

In recent years, the cost of solar panels has significantly decreased, making them one of the most accessible forms of environmentally friendly electricity generation.

A solar photovoltaic (PV) park represents an installation comprising photovoltaic panels that exploit solar energy to produce electrical power. This operation employs the use of 'photovoltaic cells', which are semiconductor devices with the ability to convert solar light into electricity, subsequently feeding it into the power grid for distribution and utilization. These cells are interconnected in both series and parallel arrangements to generate the requisite voltage and electrical output.

Utility photovoltaic parks consist of hundreds of thousands of solar panels that absorb energy from the sun, generate electricity, and distribute power to high-voltage lines. The electricity travels towards the network in consumption areas,

eventually reaching everyone's homes.

Community solar farms are small-scale solar installations that generate approximately 5 MW of electric power for local communities. This power is shared among all participants in the program.

Depending on the number of residents and the amount of electricity produced, participants can benefit from a lower energy price by investing in the solar project.

Solar panels are installed in a large, open area, ensuring that they are always facing the direction of the sun's rays. The solar energy is then delivered to the local power grid.
The electricity produced by the community solar farm powers nearby homes, while the electricity generated by utility-scale solar farms can travel thousands of miles to reach its destination.

From the point of view of the national energy mix, in 2017 solar energy had a contribution of only 2.55%, but the development potential is very high. In Romania, there are currently 7,470,000 residences, of which 3,360,000 could be suitable for the installation of photovoltaic systems. [1]

According to the Paris Agreement, in order to reach the climate objectives, set since 2016, each EU member state must reduce emissions from all sectors. As a result, new policies are needed to improve energy efficiency, stimulate the use of renewable energy, lower transportation emissions, and promote the switch to greener, more sustainable technology across a variety of industries, including energy, transportation, manufacturing, and construction.

Romania must develop new policies and conform to the new standards. To achieve this goal, it was suggested that, up to 2030, 30% of the electricity used should come from renewable sources. [2]

According to the latest reports we need even more ambitious targets, we need to reduce CO2 emissions by 100% by 2050, to stay within the 2˚C global warming limit. All this effort, however, needs the involvement and responsibility of each one of us.

In addition, the investment in such technology is recovered in about 7 years by decreasing electricity bills, as well as by increasing the market value of the building where they are placed. The panels have an expected lifetime of at least 25 years.

The closer the energy production is to the place of consumption, the smaller its transmission/ distribution losses are and, implicitly, money is saved. One solution to eliminate these costs is to opt for decentralization of the production system by creating cooperatives of small producers. Small cooperatives mean the decentralization of the national system, but not at the individual level, but at the level of communities.

Over the past ten years, the price of photovoltaic systems has fallen steadily amid increasing use. Today we find photovoltaic cells on the garden lighting system, on external batteries for mobile phones, boats, even on trains or planes. The ever-increasing promotion of this technology, the advancement of research in the field and the fact that more and more states have already implemented or are in the process of implementing policies to subsidize solar energy systems, contribute to an even greater accessibility of this technology. [3]

In the country, solar parks already exist in counties such as Giurgiu and Prahova, and the city of Brasov could soon become the first independent city in terms of electricity, thanks to the large photovoltaic parks, of 15 and 17 MW respectively, located in the region. At the end of 2021, Romania's solar power was around 1300 MW.

Currently, the construction of the largest photovoltaic park in Europe, the park in Arad County, is underway, a project that will contribute to the development of green energy and to the reduction of dependence on traditional energy sources. The photovoltaic park will have a power of 1057.5 MW. By comparison, the power of a nuclear reactor at Cernavodă, the only nuclear power plant in Romania, is 706 MW. This park will have the capacity to supply electricity for 300,000 households in Romania. [2]

The present work aims to manage the implementation actions of a photovoltaic park in a general manner, to assist anyone interested in undertaking such a business starting from the basic idea - implementation. It helps/supports them to understand which actions will be necessary to be carried out until the photovoltaic park is operational, and also the average time allocated for each action, all of which are managerial implications of the present work. Through a questionnaire-based survey on a sample, significant concerns/dilemmas/myths encountered by individuals who might wish to engage in such a business are highlighted. This work aims to provide answers to and dispel these concerns.

IMPLEMENTATION PLAN

Investment in solar energy has seen rapid growth in recent years due to the advantages it offers in terms of energy efficiency and environmental protection. A photovoltaic park can be an excellent solution to take advantage of these benefits, but to realize such a project, you must go through certain steps and meet several criteria.

If for someone who only wants to mount a few panels on the roof of the house, hoping that this will reduce the electricity bill, things are, at least in theory, relatively simple, in the case of investments in a photovoltaic park with an installed power of more than 1MW, the requirements are considerably higher.

In Figure 1 we present the nine steps of implementation plan.

The first step, **the evaluation of solar resources**, is a crucial phase in the design of photovoltaic park since it enables one to determine if a plant is feasible in a particular area. Finding out how much solar potential is accessible and how much energy can be generated annually by a photovoltaic power plant using conventional photovoltaic technology is one of the assessment's ultimate goals. [4]

Photovoltaic Geographical Information System (PVGIS) provides information on solar radiation and photovoltaic system performance for any location in Europe and Africa, as well as a large part of Asia and America. [5]

The second step, **choosing the right location,** is essential for the success of a photovoltaic park.

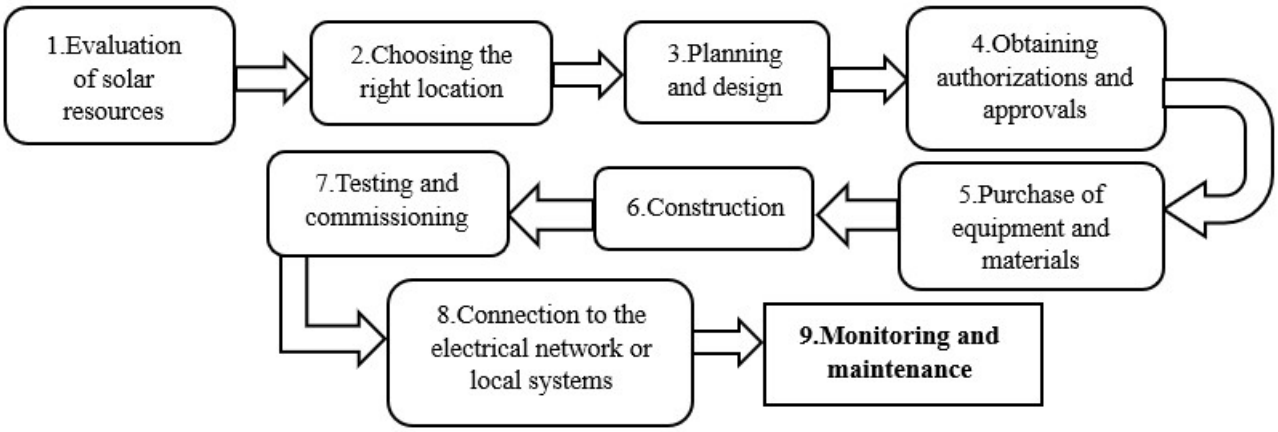

Figure 1. The way to implement a photovoltaic park

Before choosing a piece of land, it's important to take into account factors like surface area, agricultural value (which must be determined through a pedological study), access to the electrical grid, insolation and orientation (solar panels must face south and be tilted at an ideal angle to capture as much sunlight as possible throughout the day), topography and environmental conditions (the terrain should not have natural or artificial obstacles that could block or reduce the amount of sunlight reaching the solar panels, the land must not be subject to extreme environmental conditions), local regulations and restrictions. [6]

The design of the solar park involves careful consideration of every aspect that affects the efficiency and optimal operation of the park. This stage allows us to select the type and number of solar panels as well as the ideal design for the photovoltaic park. A skilled designer of solar panels can evaluate the terrain and recommend a layout that maximizes energy efficiency and reduces environmental effects. The choice of extra equipment, such as inverters, sun tracking systems, mounting systems, and electrical connections, is also included here. The choice of the right equipment and their correct dimensioning are essential to ensure the optimal operation of the photovoltaic park. Also, determining the proper location and orientation of the panels, which are critical factors in getting the most solar energy possible, is another point that needs to be considered here. And last but not least, this also includes compliance with local rules and regulations. [6]

For these projects we have quite a long list of necessary **documents and approvals**.

Before starting the construction of the photovoltaic park, it is indicated to contact the regional electricity distributor and obtain the Technical Approval for connection. All projects require obtaining an environmental permit, issued by the National Agency for Environmental Protection (ANPM) or by the county agencies for environmental protection and certifying that the photovoltaic park complies with the applicable environmental regulations. To obtain this opinion, it is necessary to draw up an Environmental Report or, in the case of larger projects, an Environmental Impact Study (SIM).

Depending on the specifics of the project and local regulations, other approvals or authorizations may be required.

After the necessary approvals, you can proceed to step 5, **the purchase of equipment and materials**. Thus, solar panels, inverters, support structures, cables and other components needed for construction can be purchased.

In step 6, **construction**, the actual construction work begins, including the installation of solar panels, wiring, inverters, and other components. It is important that all elements are installed according to technical standards and specifications. Also here, the measures to strengthen the network imposed by the technical approval for connection must be implemented. [7]

After the construction is completed, **tests and inspections** are carried out to ensure that the system works correctly and produces the estimated energy.

After the connection certificate has been issued and the user has signed a contract for the transport, distribution, and/or supply of electricity in accordance with the rules in effect, step 8 involves **the network operator completing** the final energization of the users' electrical installations within 10 days.

After commissioning, regular **monitoring and maintenance** of the photovoltaic park is necessary to ensure optimal performance and prevent potential problems. This involves checking the solar panels, support systems and electrical equipment and making repairs or replacements if necessary. [6]

Some tips for the maintenance of the photovoltaic park to be considered by the future applicants are given in the following. Periodic cleaning of photovoltaic panels is necessary. Dust or dirt can greatly reduce the efficiency of a panel. Cleaning with warm water and detergent is recommended to be done in the morning and especially during dry periods. It is also necessary to check the shading of the panels. Trees, antennas or other means can significantly reduce the production of photovoltaic panels. Next, we have the ventilation check. The fastening system of the panels should have a clear space to allow air circulation and ventilation of the panels. Overheating the panels reduces their efficiency. Finally, the angle at which the panels are mounted must be taken into account. It must favor the fall of snow in the winter and dust or dirt during the rains. [8, 9]

In the following, a Gantt diagram is presented that covers the main stages of implementing a photovoltaic park over a period approximately 2 years.

This is only an approximate example and may vary significantly depending on the project's size and complexity, local regulations, and available resources. It is crucial to consult experts in solar energy and adjust the program accordingly based on the project's requirements.

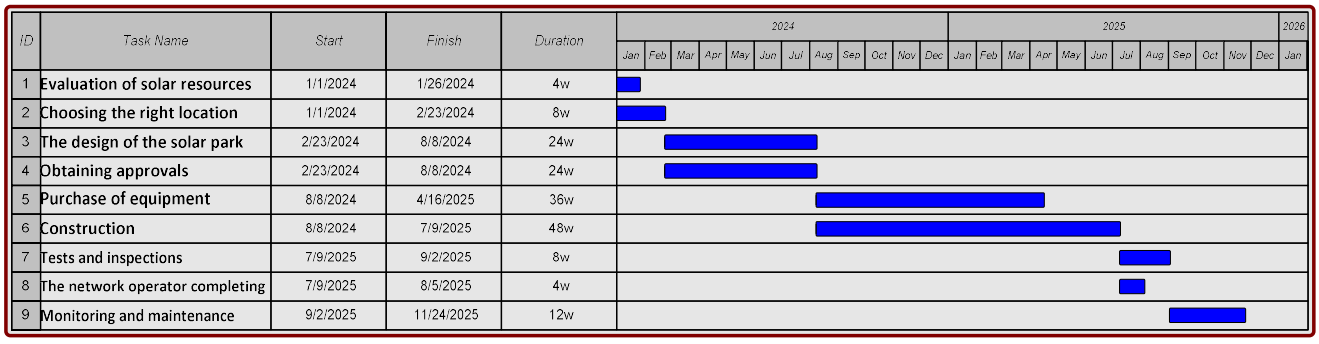

Figure 2. Project Implementation Plan

QUESTIONS AND ANSWERS REGARDING ENERGY PRODUCED BY PHOTOVOLTAIC PANELS AND IMPLEMENTATION OF A PHOTOVOLTAIC PARK

In the present paper, the researchers made a study asking the open question "What prevents you from implementing a photovoltaic park in an accessible area or even in the space of your home?". From the answers given by those interviewed, we have chosen the most relevant myths that are encountered by those who would like to apply, but do not have the courage to apply for the implementation of a photovoltaic plan. In the following we will present the myth and the corresponding answer to remove the uncertainty about them.
We used the Equation 1 to yield a representative sample:

$$n = \frac{Z^2 pq}{e^2} \quad (1)$$

where n is the sample size, Z^2 is standard normal variate, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. The value for Z is found in statistical tables which contain the area under the normal curve. [10]
We assume p=0.5 (maximum variability), a 95% confidence level and 5% precision, Z values is 1.96 and we obtain 385 surveyed individuals.
The surveyed individuals were those who possessed suitable land for the construction of a photovoltaic park, individuals interested in investing in the construction of a photovoltaic park, and individuals interested in sustainable development and renewable energy.

Myth No. 1: It is more profitable to invest in photovoltaic parks or shares in Hidroelectrica

Answer: By investing in Hidroelectrica shares, one can become part of a state-owned company with a long and stable history in electricity production. Hidroelectrica offers some investment security, as it is supported by the government and is an essential component of the country's energy infrastructure. However, looking ahead, investing in photovoltaic panels can offer several advantages.

The investment in photovoltaic panels allows the applicant to benefit from the ability to produce its own energy, which will allow protection against energy price fluctuations and also offers some independence from the traditional energy network.

Photovoltaic panels can be a constant source of income, as the energy produced can be sold to the power grid. This is an income stream that can prove more predictable and stable than stock market fluctuations.
Photovoltaic panels exhibit flexibility and scalability and can be installed at any scale, from residential roofs to large-scale photovoltaic parks, suggesting that the investment can start at any level and can be adjusted according to the needs and budget of the investor.

In addition to the direct benefits of investing in photovoltaic panels, it is preferable to consider the risks associated with stock market investments. The value of a company's stock may fluctuate dramatically depending on a multitude of factors, including overall economic performance, global events, changes in the company's management, or changes in government regulations.

Although investments in Hidroelectrica's shares may be attractive at first sight, considering the flexibility, tax benefits, energy autonomy, as well as the direct contribution to sustainability, the investment in photovoltaic panels becomes a more profitable choice for Romania's green future and for potential investors, which Hidroelectrica could not offer.

The ability to produce hydropower is restricted by the availability of water resources and the geographical location of potential new hydropower plants, limitations that may mean that although Hidroelectrica may increase production to a certain point, it will never be able to fully cover the country's energy needs.
With so much sun available in Romania, the ability to produce solar energy is virtually unlimited. Panels can be installed wherever there is a suitable surface, from roofs to halls or unused agricultural land.

Regardless of market fluctuations, revenues from photovoltaic panels remain secure, a significant advantage of investments in solar energy compared to stock market investments, where revenues can be affected by a variety of unpredictable factors. [11]

Myth Nr 2. Photovoltaic panels can be recycled and what would be the most efficient and clean method in this regard.

Answer: Yes, it can be recycled, silicon solar modules are mainly composed of glass, plastic and aluminum, three materials that are 95 to 100% recycled. Despite the recyclability of the modules, the process by which materials are separated may require advanced machinery.

It is recognized that the advantages of green energy globally are outstanding for the environment, so an active adoption of solar panel recycling processes can provide additional business opportunities and advanced methods of environmental protection.

According to estimates, about 90 million tons of waste from photovoltaic panels can accumulate by 2050. In order to prevent them from reaching a large landfill, where they can release toxic substances that can significantly affect the environment and the health of the entire planet, it is imperative to recycle these panels in a controlled manner. In addition, recycling can provide a new source of raw materials that can then be reused. Currently, there are three main methods for

recycling them. One would be reuse/reconditioning, the preferred method of recycling, which requires few processing processes. This method is suitable for small off-grid applications. In addition, it is viable in the case of specialized solar microsystems, such as lighting electronic signs on highways or charging electric bicycle stations. A second method is mechanical recycling, a method that involves the physical dismantling of photovoltaic panels into individual components and that requires more time and precision. Machines can be used in the process of separating smaller components, such as cables and solar cells, by physical processes. And last but not least, there is the chemical/thermal recycling method, which involves reactions at the molecular level for separating the ingredients of a solar panel.

Photovoltaic panels being composed of several recyclable materials, in the recycling process, all reusable materials are processed separately by: separating metal components that are 100% recyclable; separating glass from the rest of the photovoltaic panels, which can be recycled in a proportion of 95%; thermal process. In this process, the rest of the material in the solar panel is heated to above 480 C, a step that vaporizes the plastic, which can then be used as a heat source for further processes. Another method is the separation of silicon components, which is done by a chemical process. Approximately 85% of the silicon contained in photovoltaic panels can be recycled.

There is a legal framework at the level of the European Union, as well as recycling centres for obsolete panels. Currently, the largest photovoltaic panel recycling plant in Europe based in France, Grenoble, has been inaugurated, a factory that specializes strictly in the recycling of these panels, through the start-up ROSI. [12]

Myth No. 3: Photovoltaic energy is too expensive

Answer: The price of photovoltaic systems has decreased every year for the last 20 years by an average of five percent. The investment in a well-designed and installed photovoltaic system is amortized in 7 years. In recent years, the price of energy has increased, and the trend will be maintained, this leads to the reduction of the amortization period of the investment. In addition, photovoltaic energy systems add value to the property. [13]

Myth No. 4: Photovoltaic panels are useless in winter

Answer: Photovoltaic panels produce energy based on the amount of sunlight they are exposed to, regardless of the season. Photovoltaic panels are less efficient at very high temperatures or if they are covered with dust or snow.

Photovoltaic panel insurance is essential to protect your solar investment and ensure adequate coverage in the event of damage or breakdown. Photovoltaic panels are a green and sustainable energy source that can reduce energy costs and environmental impact. To get the most out of this advanced technology, it is also important to consider the proper insurance of these panels.

Solar panel insurance can vary by policy and insurance provider, but generally it covers: property damage caused by fire, theft, vandalism, high winds, hail, falling objects and other unforeseen events; technical or electronic failures of photovoltaic panels; energy production losses caused by breakdowns or damage; water damage, including flooding or leaks in the photovoltaic system; damage caused by animals or birds; the risk of civil liability for damages caused to third parties in connection with the photovoltaic system. [13]

Myth No. 5: Photovoltaic panels require high maintenance cost

Answer: Photovoltaic panels have no moving parts, so they do not involve expensive maintenance expenses. Dust can reduce the efficiency of the panels by about 5%, and it is recommended to clean them once a season. Many photovoltaic systems are equipped with monitoring programs that will immediately identify any factors that reduce energy generation, alerting the user to the need to clean the panel. [*1*]

Myth No. 6: The photovoltaic park must be kept in perfect working condition

Answer: First of all, maintaining the photovoltaic park in perfect working condition would be by removing the vegetation around the photovoltaic panels, which can be done several times a year, and the preventive maintenance of the electrical equipment is usually carried out once a year. In order to prevent the landowners from being perturbed during scheduled or unplanned maintenance, the photovoltaic park will require a dedicated access road and a fence around the location. [12]

Myth No. 7: Should I buy or lease my solar panel system?

Answer: Depending on why you want to go solar, you can choose to either buy or lease your solar energy system. Buying the system is definitely a better choice for you if you want to maximize the financial benefits of your solar energy system. A solar lease is something to think about, though, if you prioritize an easy, upkeep-free approach to save your energy costs and benefit the environment. [14]

CONCLUSIONS

The use of renewable sources such as solar-photovoltaic to produce electricity will have the consequence of reducing the quantities of fossil fuels consumed, with a positive impact on environmental factors, by reducing the quantities of gaseous, solid and liquids pollutants.

The installation of a photovoltaic park is a complex process that involves going through several stages and meeting a series of criteria. From choosing the right land, carrying out the pedological study, obtaining the technical approval for the connection and the necessary authorizations, to the construction, connection to the network and maintenance of the park, each step must be carried out with care and professionalism to ensure the success of the project.

Investing in solar energy brings many benefits, both economically and environmentally, and can be a viable and sustainable solution for the future of energy production. Therefore, it is essential to understand and respect the process of installing a solar farm to ensure that these projects are carried out efficiently, safely and responsibly.

By investing in photovoltaic panels, we have the opportunity to significantly reduce our dependence on energy imports. Solar energy can be produced locally, directly where it is needed, eliminating the need for expensive energy transport over long distances.

One of the most attractive aspects of investing in solar panels is the stability of income they provide. Although the price of energy in the open market can fluctuate due to a variety of factors, including changes in demand, variations in production costs, and changes in energy policies, revenues from solar power remain largely stable and predictable.

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