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O 21. SOLAR POWER ELECTRICITY IN PUBLIC BUILDINGS ECO-FRIENDLY ENERGY SOLUTION– CASE STUDY THE ALBANIAN FOOTBALL ASSOCIATION BUILDING

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ABSTRACT: During the last years, there has been a surge in electricity demand, coupled with a significant surge in energy prices. The primary source of electricity generation in Albania is hydroelectric plants, and this relies heavily on atmospheric conditions. According to data from the Albanian Energy Corporation, these hydroelectric plants typically provide about 70–80% of the country's annual electricity consumption. The conversion of solar energy into electricity through photovoltaic panels (PV) has become increasingly cost-effective and technologically advanced, spanning various cost-efficient applications, which has raised the interest of private companies and several photovoltaic parks are in various stages of development in Albania. This article focuses on an in-depth examination of electricity production via photovoltaic panels for a public building, namely the Albanian Football Association. Based on measurements taken at the facility, it is evident that the electricity generated by the PV panels is sufficient to meet the energy demands of the company, with occasional surplus energy production. It is crucial to emphasize that the installation of photovoltaic panels for electricity generation is both necessary and highly efficient. Representing a key facet of renewable energy sources, solar energy has garnered significant interest as a sustainable and eco-friendly energy solution.

Keywords: Solar Power, Energy, Eco-Friendly Energy, Public Building, Sustainability.

1. INTRODUCTION

Electricity today is a basic human need. In 2022 most of the nation's electricity production is based on fossil fuels such as oil, coal, gas. These fossil materials are exhaustible and their burning has harmful effects on the environment, climate and health. Due to these limitations and with the continuous increase in the demand for electricity, the only alternative left is the production of electricity from renewable energy sources such as the use of energy from solar power, wind, hydropower, biomass, and geothermal. Now with the technologies we have, it is a smart solution to produce free electricity from nature.

1.1. Electricity Production in Albania

Historically during the last decades, electricity production in Albania primarily has relied on hydropower plants, with the most significant ones located along the Drin River. Over the past decade, Albania has seen the construction of numerous small hydropower facilities, with a total of around 600 MW in capacity (Energy Regulatory Entity-ERE, 2021). Consequently, electricity generation is contingent on weather conditions and precipitation. Albania's energy production sector encounters challenges in providing sufficient electricity to consumers, stemming from issues such as a scarcity of primary energy resources, the absence of a natural gas distribution network, restricted transmission line capacities for interconnection, and complete reliance on hydropower for energy production.

At the other hand, there has been a significant surge in electricity demand within the country. The electricity generated by power plants at a given time falls short of meeting consumer needs. Consequently, to meet this demand, a portion of electricity is imported from other countries.

Also in recent years, there has been a notable upturn in electricity prices, posing challenges for both residential users and the industrial sector. In certain instances, due to these rising electricity costs, some companies have been compelled to cease their production processes, leading to a ripple effect on the nation's economy.

In light of the issues plaguing the electricity sector, many consumers are exploring alternative means of obtaining electricity (Solar Power Europe, 2017). One of the most effective methods for electricity production involves harnessing solar energy through the installation of solar panels. Over the past few years, the cost of solar panels has decreased, prompting increased interest from the public and private sector in their adoption.

2. MATERIAL AND METHODS

In this article, we will examine a case study that focuses on electricity generation using solar panels at the facilities of the Albanian Football Federation. The Albanian Football Federation (Albanian: *Federata Shqiptare e Futbollit*; FSHF) is the governing body of football in Albania. The association is based in Tirana, Albania. The installation of photovoltaic panels not only met the Federation's energy needs but also contributed surplus energy to the grid.

The benefits of utilizing solar panels for electricity production include ease of installation, minimal maintenance requirements, a short installation timeframe, and their eco-friendly nature.

However, a drawback is that photovoltaic panels necessitate a significant surface area and generate power exclusively during sunny hours. The sun in one hour radiates enough energy to cover the energy consumption used by people in a year.

2.1. General Overview

Albania, with a favourable geographical position in the Mediterranean basin, has very favourable climatic conditions for the use of solar energy. The high intensity of solar radiation, the duration of this radiation, the temperature and humidity of the air, etc. the Mediterranean climate, with a mild and wet winter and hot and dry summers, determines an energy potential greater than the average energy potential for the use of solar energy.

Most of the energy is the result of direct or indirect activity of the sun. Direct solar energy has begun to be widely used in power generation through solar panels, photovoltaic panels, solar parks, etc.

In the territory of Albania, we have a considerable solar energy potential, there are about 286 sunny days, with up to 2700 sunny hours per year, where many areas are exposed to a radiation ranging from 1185 kWh/m^2 per year to 1700 kWh/m^2 per year.

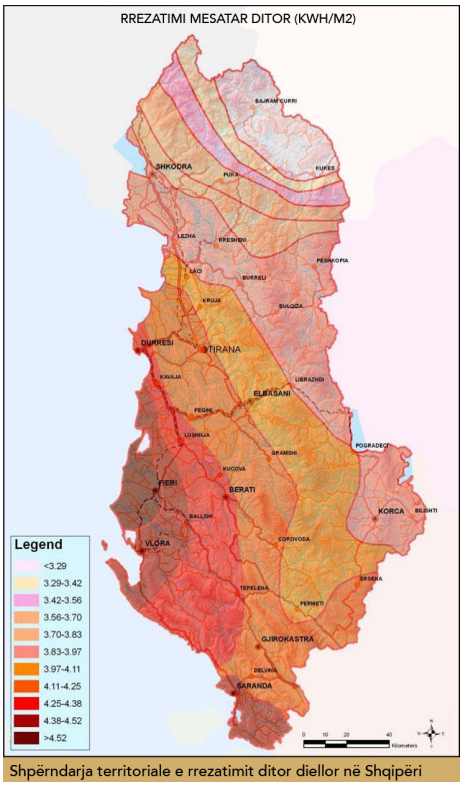

Figure 1. The territorial distribution of the annual sunny hours in Albania

2.2. Photovoltaic Potential in Albania

Albania, being located in the Mediterranean region, has a great potential of solar radiation and has suitable conditions to exploit solar radiation throughout the country and especially in the coastal regions.

Table 1. Optimum slopes of the installation angle in different countries

Vendodhja	Pjerrësia optimale e këndit të panelit diellor
Tirana	
(Shqipëria)	41°
Prishtina	
(Kosova)	42°
Shkup	
(Maqedonia)	42°
Podgorica	
(Mali I zi)	42°
Berlin	
(Gjermani)	52°
Athina	
(Greqi)	37°

Albania has an increased consumption of electricity in the summer, while the local production of electricity in the summer is smaller. This is because;

a) Over 95% of energy in Albania is produced by hydropower plants, (in summer there is little rainfall).

b) Many small hydropower plants cannot operate during the summer months, as water is needed for agriculture.

c) The energy demand of the tourism industry is mainly focused on the period June - October. In these 5 months, about 80% of the accommodation is about ¾ of the annual energy needs

d) Albanian agriculture in summer has high energy consumption, which is necessary to irrigate their fields. This is mainly done by electric pumps, or pumps with fuel generators.

e) Families as well as state institutions use a lot of energy for air conditioners and waste electricity for heating hot water

Table 2 provides statistics regarding electricity production in Albania for the year 2021 :

across all producer categories (ERE, 2021). Notably, Table I illustrates that Korporata Elektroenergjitike Shqiptare J.s.c. (KESH), a publicly owned company, made the most significant contribution to energy production in 2021. Additionally, the data in Table I indicates that photovoltaic facilities generated 40,756 MWH, constituting approximately 0.5% of the total energy production for the year 2021. Albania, owing to its advantageous location in the Mediterranean region, boasts favourable climatic conditions for leveraging solar radiation in electricity generation. The energy potential of solar energy is determined by factors such as the intensity and duration of solar radiation, temperature, humidity, and other related variables.

Albania's territory is situated in the western portion of the Balkan Peninsula along the eastern coast of the Adriatic and Ionian seas. Geographically, it spans between latitudes 39° 38' - 42° 38' and longitudes 19° 16' - 21° 04'. Within our country's borders, there exists a significant solar energy potential, with numerous areas receiving annual radiation ranging from 1,185 kWh/m^2 to 1,700 kWh/m2. Notably, the western part of Albania, particularly the southwest region, enjoys substantial solar energy resources, which can reach up to 2,200 kWh per year.

Figure 1 delineates an isoline marking 1,500 kWh/m^2 per year, effectively dividing Albania's territory into two nearly equal segments (NANR, 2015). Each square meter of horizontal surface within this delineated zone has the practical potential to receive up to 2,200 kWh/m^2 annually. Irrespective of prevailing weather conditions, the same surface typically captures approximately 1,700 kWh per year.

Table 2. Energy production of the year 2021

Type of generation	Yearly energy
PPE/ hydropower	877,726
PPE/ hydropower	951,505
Private hydropower	1,425,989
Lanabregas hydropower	27,504
Ashta hydropower	295,245
Photovoltaic plant	40,756
Hydropower menage by	5,343,974
TOTAL	8,962,699

Table 3 presents data on the average solar energy production capacity in various regions over the course of the year. The data from the Tirana and Vlora regions, where public services and industrial operations are concentrated, reveal that the daily solar energy capacity surpasses that of other regions.

Table 3. Yearly radiation (kWh/m^2 per day)

Region	Shkoder	Diber	Tirana	Vlora	Korça	Saranda
January	1.70	1.55	1.80	2.15	1.90	1.90
February	2.30	2.30	2.50	2.85	2.70	2.40
Marty	3.35	3.25	3.40	3.90	3.40	3.60
April	4.50	4.15	4.20	5.00	4.40	4.80
May	5.45	5.25	5.55	6.05	5.60	5.80
June	6.10	5.85	6.40	6.80	6.40	6.80
July	6.50	6.25	6.70	7.20	6.80	6.10
August	5.55	5.45	6.05	6.40	5.90	4.80
September	4.45	4.35	4.70	5.15	4.70	3.60
October	2.90	2.90	3.20	3.50	3.10	3.20
November	2.10	1.85	2.15	2.40	2.10	2.10
December	1.70	1.50	1.75	1.85	1.80	1.80

Table 4 provides information on the solar plant installations in Albania up to 2021, as well as the solar energy production in the year 2021.

Table 4. Yearly solar energy production

Solar plant	Installed capacity	Grid connection	Energy production
	MW	kV	MWH
“seman2sun”	2	35	4,021
"Sonne"	2	35	4,001
“aed solar”	2	35	4,001
“age Sunpower"	2	35	3,950
“Seman Sunpower”	2	35	4,049

"Semanisolar"	2	35	3,950
ES 2019	2	35	4,304
"Smart watt	2	35	4,290
RTS	2	35	3,668
Statkraft	2	35	13
AEE	2	10	4,469

Solar energy holds great promise as a future energy source due to its potential as an abundant, renewable, and widely distributed natural energy reserve. It is both plentiful and clean, requiring no additional expenses, and it poses no environmental pollution risks (Alirezaei et al, 2016).

2.3. Residential Solar Systems

Large photovoltaic systems are called residential solar systems. They typically provide electrical energy for large installations such as hotels, hospitals, schools, factories, etc., and offer a wide range of load application possibilities. These systems produce from 500W to 4000W with a 12V, 24V, or 48V battery system, depending on the system's power capacity (see Figure 2).

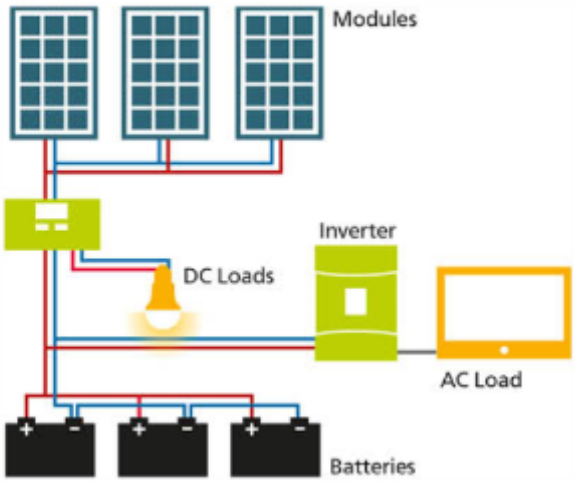

Figure 2. Residential dual-connection DC/AC system

2.4. Solar Energy's Impact on The Power Grid

Using photovoltaic technology for electricity generation has brought about significant enhancements in the efficient utilization of water resources in Albania. Furthermore, the deployment of photovoltaic systems has substantially curtailed the need for electricity imports from external regions. Currently, the process of obtaining permits to establish power facilities, such as solar or wind farms is encumbered by excessive bureaucracy. Should the energy market become more open, especially with regard to photovoltaic technology, it would exert a noteworthy influence on the energy sector. In fact, recent years have witnessed the issuance of licenses for the construction of several photovoltaic parks with power capacities ranging from 2 to 100 MW.

However, as the number of solar installations increases within the power grid, certain challenges have emerged. The primary issue encountered pertains to power quality, as pointed out by Mohamed A.E. and Zhengming Zh. in 2010 (Mohamed & Zhengming, 2010). Apart from the fundamental harmonic, the voltage and current waveforms produced by the inverter exhibit high-order harmonics.

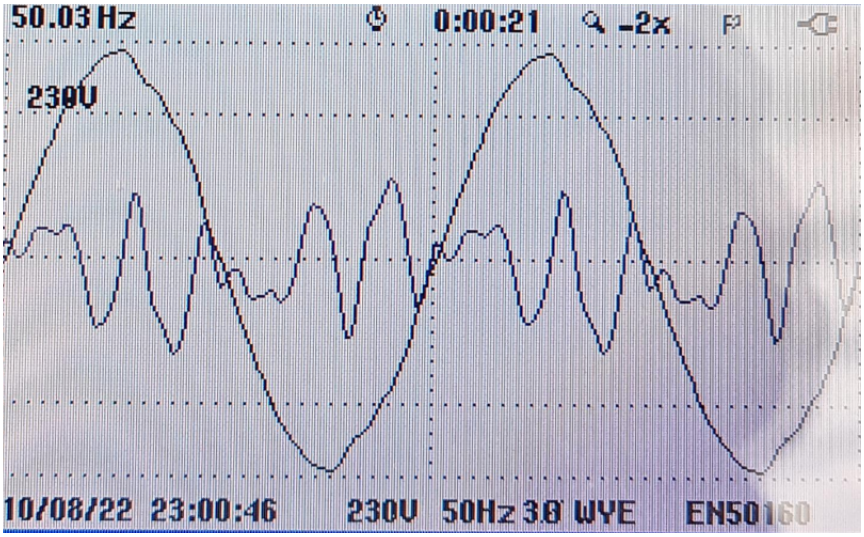

Figure 3. Voltage and current waveform of the inverter.

Figure 3 displays the distorted voltage and current waveforms at the inverter's output. Furthermore, the introduction of nonlinearities, alongside nonlinear loads, can be attributed to harmonic sources like non-sinusoidal waveforms emitted by solar PV inverters, as highlighted by Ahsan S. et al. in 2021 (Ahsan et al., 2021). Presently, inverters are expected to feature high-quality switching, producing pure sinusoidal waves. However, substandard inverters mostly produce modified sine waveforms for current and voltage at their output, leading to contamination of the low-voltage (LV) grid (Chidurala, et al. 2014), where the current spectrum is dominated by the 5th and 7th-order harmonics.

The presence of high-order harmonics in the voltage output of the inverter poses issues for the power grid. Consequently, steps should be taken to mitigate these problems, such as the installation of reactors in series, as proposed by Zhang Y. et al. in 2019 (Zhang et al., 2019).

Hence, prosumers participating in net metering programs need to introduce both active and reactive power into the grid (as indicated by Sara E. et al. in 2013). In many instances, the existing transmission and distribution lines are insufficient to accommodate the energy injection from solar panels. Therefore, besides establishing photovoltaic facilities, it becomes essential to contemplate the creation of new substations and expand the transmission and distribution power lines. When solar panels generate electricity, there is an elevation in voltage levels beyond the permissible limit.

Additionally, another challenge associated with generating energy using photovoltaic technology is the abrupt fluctuations in energy output caused by weather conditions. These fluctuations place pressure on hydropower plants, which play a crucial role in stabilizing the energy supply within the power system.

3. DISCUSSIONS AND FINDINGS

3.1. Photovoltaic Panels at The Albanian Football Federation

The photovoltaic system has been installed in the "Albanian Football Federation" facility at the beginning of 2021 year. The building is situated at Liman Kaba, Nd 5, Entrance 1, Administrative Unit 5, Tirana, Albania. The Federation's central offices are located on the building's terrace, and the decision to install solar panels stems from the desire for clean energy and to reduce the monthly electricity expenses. The investor is attracted to this project due to its alignment with legal requirements and its adaptability to changes in the Electricity Distribution Operator Sh.A (or OSHEE) network.

As previously mentioned in the introduction of this paper, there has been a growing fascination with generating electricity by installing photovoltaic panels in the past years. In this section, we will delve into a case study that explores the installation of these panels in the Albanian Football Federation facility.

The investor will utilize the energy generated by this PV system to meet their own needs, consequently reducing their electricity bills.

Table V shows the energy consumption and billing by OSHEE for the month of September for each year of the period 2020-2023. The figures of the September 2020 are before the installation of

photovoltaic elements connected to the electrical system, while the rest (figures of the years 2021, 2022, 2023) are after installation and use of the photovoltaic system.

Table 5. Energy consumption, and energy billing by OSHEE for the September 2020 /2021/2022/2023

Albanian Football Federation invoice by OSHEE				
Bill Period	**KWH (Active)**	**KVArH (Reactive)**	**Peak**	**Total Amount ALL**
September/2023	10224	0	2464	284,153
September /2022	21680	0	-	477,233
September /2021	38080	0	-	566,730
September /2020	132880	0	-	1,977,554

Table 5 obviously indicates the significant decrease of the energy consumption and billing from the year 2020 (conventional function) and the year 2023 (use of the photovoltaic system). Comparison of the two years 2020 and 2023 indicates a decrease by 85.6%.

Our country's current strategy places high value on the use of renewable energy as an economic development priority. Hence, the objective of this project is to employ renewable energy for power supply.

The modules chosen for this system are JA Solar (JAM72S30 525-550/MR), which meet the necessary European CE certification standards. They have dimensions of 2279 X 1134 X 35 mm and offer a panel power rating of 540 W.

There are many contemporary inverters which are equipped with internal components that, leveraging the maximum DC power they receive, automatically adapt their output impedance to optimize power output. The typical efficiency range for inverters, which is both recommended and suitable for this scenario, falls between 96-98%. Furthermore, the inverter serves as a safety mechanism for the system. It is designed to disconnect its output in the event that voltage, current, or frequency surpasses the predefined limits. In this context, the solution would involve using a single inverter with a nominal power capacity exceeding the photovoltaic system's power production by up to 120%.

4. CONCLUSIONS

In summary, given Albania's favourable solar radiation conditions, it holds the potential to generate energy from solar plants. Solar power is a highly promising and sustainable energy source for the future. After examining the content of the article, the following key points can be drawn:

- Solar energy is both cost-free and limitless.
- Solar power is environmentally friendly and does not produce pollution.
- Utilizing photovoltaic plants for electricity production can lead to more efficient water resource utilization within the country.
- Solar energy doesn't release greenhouse gases or harmful waste products.
- Solar power is especially beneficial for generating electricity in remote areas or where expanding the utility grid is costly.
- Solar panels, thanks to their straightforward design and low maintenance expenses, are primarily used for power generation.
- Efforts should be made to enhance the construction of new power lines and substations within the electric distribution and transmission networks to incorporate energy from photovoltaic plants.
- The energy market, particularly in terms of granting licenses for residential and industrial photovoltaic plant installations, should be liberalized.

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