PROSTORNO - ENERGETSKA ANALIZA POTENCIJALNE TRANSFORMACIJE TERMOELEKTRANA U SOLARNE ELEKTRANE NA TERITORIJI KOSOVSKOG OKRUGA

SPATIAL – ENERGY ANALYSIS OF THE POTENTIAL TRANSFORMATION OF THERMAL POWER PLANTS TO SOLAR POWER PLANTS ON THE TERRITORY OF KOSOVO DISTRICT

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Sagorevanjem fosilnih goriva u termoelektranama oslobađa se velika količina zagađujućih materija čija prekomerna imisija u vazduhu dovodi do zdravstvenih problema stanovništva koje živi u blizini, ali i do narušavanja stanja svih elemenata životne sredine. Radom termoelektrane u opštini Obilić i emisijom polutanata iz pomenute, zdravstveno je ugroženo skoro čitavo područje Kosovskog okruga. Metodom valorizacije i eliminacije, u radu su analizirani prirodni i antropogeni uslovi koji imaju najveći uticaj na potencijalnu izgradnju solarnih elektrana, koje bi u potpunosti zamenile rad termoelektrane i svu količinu električne energije koja se dobija sagorevanjem uglja. Primenom geografskih informacionih sistema (GIS), analizirani su i interpretirani faktori koji utiču na prostorni razmeštaj potencijalnih solarnih elektrana: nagib terena, ekspozicija reljefa, način korišćenja zemljišta, zaštićena područja, blizina saobraćajnica i blizina naselja. Obradom pomenutih faktora, dobijaju se tematske karte na kojima se izdvaju najpogodnije površine. Sintezom tematskih karata, dobija se sintezna karta koja daje adekvatan prikaz pogodnih lokacija za izgradnju solarnih elektrana. U radu je izvršena i uporedna analiza snage postojeće termoelektrane sa potencijalnim instalisanim snagama solarnih elektrana koje bi u potpunosti snabdevale prostor Kosovskog okruga, ali i ostale okruge na teritoriji A.P. Kosovo i Metohija.

Ključne reči: Solarne elektrane; pogodne lokacije; energetika; Kosovski okrug; GIS

Combustion of fossil fuels in thermal power plants releases large quantities of pollutants, the excessive air emission of which leads to health problems of the nearby population but also the disturbance of the state of all elements of the environment. The operation of the thermal power plant in the municipality of Obilić and the emission of pollutants endanger the population of Kosovo District in a health and ecological sense. By valorization and elimination methods, the paper analyzes the natural and anthropogenic conditions that have the most significant impact on the potential construction of solar power plants which would completely replace the operation of the thermal power plant and all the quantity of electricity generated by coal combustion. Geographic information systems (GIS) were used to analyze and interpret factors affecting the spatial distribution of potential solar power plants: terrain slope, relief aspect, land use method, protected areas, the proximity of roads and settlements. By analyzing the above factors, thematic maps showing the most suitable surfaces were obtained. Overlaying of thematic maps gave a synthesis map which provides an adequate view of appropriate locations for the construction of solar power plants. A comparative analysis was done between the strength of the existing thermal power plant and the potential installed powers of solar power plants which would fully supply the area of Kosovo District, as well as other districts in the territory of A. P. Kosovo and Metohija.

Key words: Solar power plants; suitable locations; energetic; Kosovo District; GIS

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1 Introduction

Increasing the generation of electricity from renewable energy sources today is one of the main goals of humankind. Due to the limited amount of oil, coal and gas, as well as their negative impact on the environment, it was necessary to find an alternative that would generate electrical and thermal energy without major consequences for the environmental quality and human health [1]. One of the most acceptable renewable energy sources is solar energy. More energy from the sunlight strikes the earth in 1 h than all of the energy consumed by humans in an entire year [2]. On average, Serbia has more sunny hours than most European countries [3]. Specific physical, geographical, and infrastructural characteristics of Kosovo Administrative District have been analyzed using the geographic information systems. Kosovo District consists of the following municipalities: Štrpce, Kačanik, Uroševac, Štimlje, Lipljan, Glogovac, Kosovo Polje, Pristina, Obilić and Podujevo.

The total area of the district measures 3122.34 km^2. „Kosovo A" and „Kosovo B" thermal power plants emit significant amounts of pollutants that contaminate the environment and impair the health of the population. These thermal power plants (TPP) are located in the Obilić - Priština direction, and they use low-calorie coal - lignite to obtain electricity. Combustion of coal releases a large amount of SO_2, CO, and other gases that reduce air quality and often increase the acidity of soil and water (acid rain). The soot and dust that are released from chimneys get into the atmosphere and accumulate in the human body through the respiratory organs, causing breathing difficulties. The paper presents the identification of suitable locations for the construction of solar power plants that would significantly reduce the environmental and health consequences, while at the same time accommodating the needs for the energy of the whole population in the Kosovo District.

2 Materials and methods

GIS software packages GeoMedia Professional and QGIS were used to determine suitable locations for solar power plants. The method of work was cabinet work and provided efficient and easily accessible data that can be largely used for the analysis of natural conditions and obtaining analytical and synthesis maps.

Five thematic maps were analyzed to find suitable locations for solar power plants and their evaluation, based on which a final, synthesis map of benefits was formed.

The land aspect map (S_1) is one of the most significant maps in the valorization of locations for solar power plants. Valorization was done based on the terrain solar exposure, where terrains with southern aspect were identified as the most favorable locations due to pronounced insolation, while the least favorable location was north because of the significantly less solar exposure.

The terrain slope angle map (S_2) represents the degree of terrain slope. The most favorable locations for the construction of solar power plants are the (most accessible) terrains with low angle slope (0.5-3°).

The Corine Land Cover [4] base, from which classes of land use were taken, was used to obtain the third, land use map (S_3).

The buffer zone around the roads (S_4) is an essential anthropogenic factor in determining the suitable locations and the subsequent realization of the construction of solar power plants, i.e., more accessible and more efficient construction of potential solar power plants. Depending on the proximity of the road, buffer zones were determined and assessed based on the area proximity to main roads.

The buffer zone around the settlement (S_5) is also a crucial anthropogenic factor. Large areas under solar power plants operating on the principle of the photovoltaic effect in solar panels emit a large dose of electromagnetic radiation, adversely affecting human health.

In this paper, a 500 m buffer zone is set up around the settlement to protect the population from non-ionizing radiation. When it comes to protected areas, the largest part of the municipality of Štrpce is located within the Šar Mountains National Park, and in this territory, it is possible to build individual roof solar plants that would not endanger the ecological balance.

Table 1: Buffer zone around roads

Buffer zone	Grade
0 – 300 m	5
300 – 600 m	4
600 – 900 m	3
900 – 1200 m	2
> 1200 m	1

Based on the analysis of 5 maps, the final map of the advantages of the locations for the construction of solar power plants is obtained:

$$S_k = \frac{\sum_{i=1}^{5} S_i}{n} = \frac{S_1 + S_2 + S_3 + S_4 + S_5}{5}, \text{where}$$

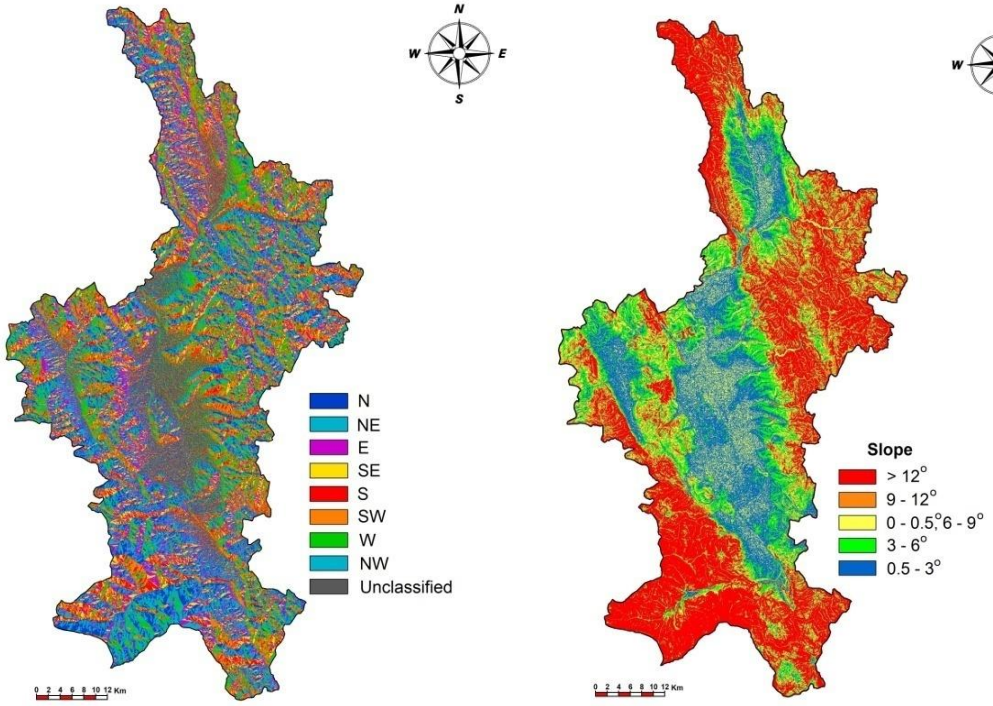
S_k - synthesis map, S_i - individual maps n - number of maps

By analyzing the synthesis map and locations most suitable for construction, a calculation was made to obtain the potential installed capacity of solar power plants. The processed factors include the area of solar panels, the area of the most suitable locations, the capacity of solar panels, and potential investment.

3 Results and discussion

Solar photovoltaic panels play an extremely important role in electrical energy production in many countries [5]. Direct conversion of solar into electrical energy, the so-called photovoltaic effect, was observed almost two centuries ago, but only by the development of quantum theory in the early 20th century this phenomenon was explained and un-derstood [6]. Photovoltaic conversion of solar radiation takes place in PV solar cells made of semiconductor materials [7].

With the use of GIS, the geomorphological characteristics of terrain aspect and slope were processed and showed on the map.



Figures 1 and 2: Terrain aspect and slope maps

The accessibility and availability of solar power plants are significantly influenced by the terrain slope. In the central part of the district, the highest slope is 0.5 - 3°, which favors the con-

struction of solar power plants to the greatest extent. Flat terrains below 0.5° often impede normal water outflow, so water is often retained in this area after significant precipitations.

Water retention in the area intended for solar power plants would jeopardize the installation and lead to potential defects. Due to inaccessibility during construction and difficult maintenance of power plants, high slopes are avoided [8].

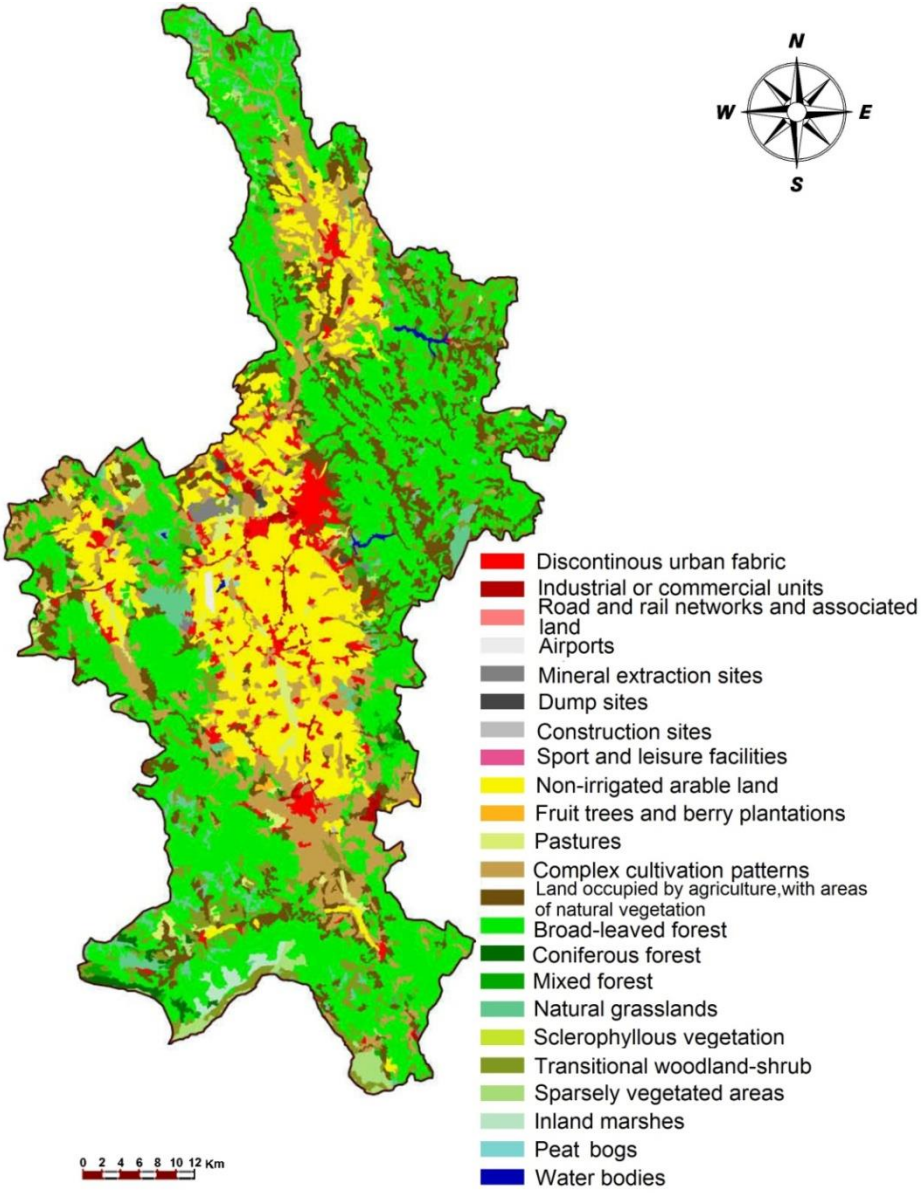


Figure 3: Land use map

The method of land use depends on the natural and anthropogenic effect [9]. Unirrigated agricultural areas are selected as the most suitable locations, which are mostly represented in the central part of the district.

The buffer zones around the roads are a factor in accessibility for the construction of potential power plants, so the areas closest to the main roads are the most suitable. The buffer zone is set fixed about 500 m around the settlement to prevent the impact of excessive electromagnetic radiation on the local population.

A synthesis map of benefits for the construction of solar power plants on the territory of the Kosovo district is obtained based on the research of the previous analytical maps.

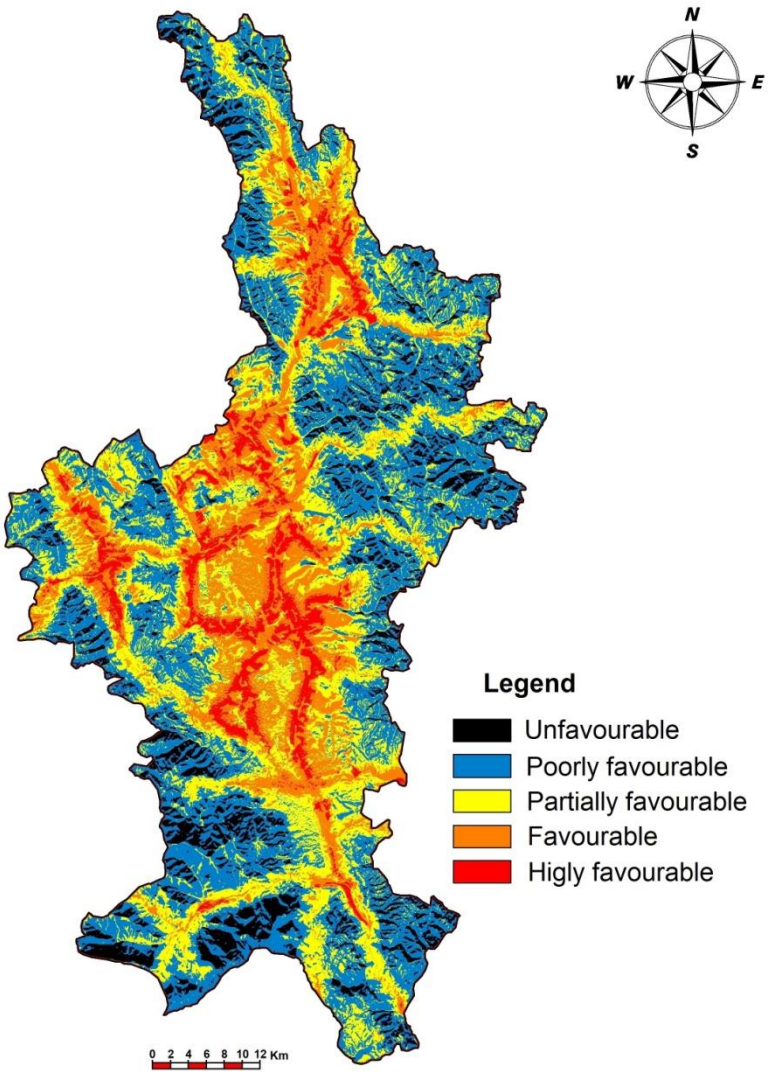


Figure 4: Sythetic map of sutability

On the synthesis map, we find that the most suitable locations for the construction of solar power plants are the central and northern part of Kosovo District.

Table 2: Evaluation of location benefits by municipalities

Municipalities	Podujevo	Prishtina	Kosovo Polje	Obiliq	Glogovac	Lipljan	Stimlje	Uroševac	Strpce	Kačanik
Unfavorable	54.34	65.28	1.09	1.78	13.52	20.23	15.04	35.3	51.24	46.41
Poorly favorable	262.62	266.72	12.96	15.54	117.26	111.11	47.67	107.99	118.06	151.85
Partially favorable	168.54	139.26	24.5	33.02	86.7	102.49	32.59	110.27	53.97	85.77
Favorable	113.46	75.08	46.06	39.06	57.42	117.73	27.23	82.45	8.4	17.67
Exceptionally favorable	30.11	20.07	14.85	17.49	19.9	49.06	13.96	14.13	1.31	3.81

Favorable and exceptionally favorable areas for the construction of solar power plants are mostly located in the municipalities of Lipjan, Podujevo, Priština, Glogovac, Uroševac, and Kosovo Polje. It is possible to build one solar power plant in each these municipalities that would replace the thermal power plants energetically.

According to the existing data [10], the „Kosovo A“ and „Kosovo B” thermal power plants together have an installed capacity of 1235 MW that supplies most of Kosovo and Metohija with electricity.

Since the municipality of Lipljan is the most suitable for the construction of solar power plants, it is in this municipality that the most extensive system of solar panels in Kosovo District would be built.

Table 3: Capacity of potential solar power plants in the territory of Kosovo District

Municipality	Solar power plant area (km^2)	Installed capacity (MW)
Ljipljan	10.56	456.5
Uroševac	5.28	228.25
Glogovac	5.28	228.25
Priština	5.28	228.25
Podujevo	5.28	228.25
Kosovo Polje	5.28	228.25
Total	36.96	1597.75

The power of the solar panels would be 275 Wp, and the area of such a solar panel would be around 1.72 m^2. The accompanying equipment, that is, the entire electrical system for the construction of a solar power plant must be considered. The total installed capacity of all solar power plants would amount to almost 1600 MW, which would be sufficient for the energy needs of the population.

Prior to the construction of a solar power plant, it is necessary to do an environmental impact assessment. This is a big venture that would require time and significant investments that would almost certainly exceed 1 billion euros, but after the construction, the investment would be zero for the next 20 years, which is also the warranty period given by factories that manufacture solar panels.

Despite significant investments, solar power plants would be economically viable, as the costs of coal exploitation, transport, and combustion in thermal power plants are higher over a longer period. A large part of the costs could be covered by the organizations of the developed countries, which at the conference held in Copenhagen in 2009 expressed their readiness to allocate significant resources (up to $ 100 billion annually) to assist developing countries and their transition to clean energy [11].

4 Conclusion

The most suitable areas for the construction of solar power plants in the territory of Kosovo Administrative District have been identified with the use of GIS. The potential is significant enough to see in the future the solar power plants in 6 municipalities replacing „Kosovo A” and „Kosovo B” power plants in electricity generation for the majority of the population in the territory of AP Kosovo and Metohija. The transition from non-renewable to renewable energy sources will improve the quality of people's lives, but it is necessary to change consumer habits and rationally use electricity.

The goal of sustainable development is to achieve economic and ecological balance. The whole project would be economically justified, and the environmental and health significance would be immeasurable. Polluting particles in the atmosphere would decrease year by year, the soil would be more fertile, and the water would be cleaner. The health status of the population would be significantly improved due to the lower emission of pollutants in the air.

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