PLANIRANJE SOLARNIH ELEKTRANA I ŽIVOTNA SREDINA

SOLAR POWER PLANT PLANNING AND THE ENVIRONMENT

Boško Josimović

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dr Boško Josimović

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PREDGOVOR

Nakon knjige „Prostorni apekti uticaja vetroelektrana na životnu sredinu” (2017, engl. izdanje 2020), prve koju sam posvetio „zelenoj” energiji, a usled ekspanzije u korišćenju obnovljivih izvora energije (OIE), osetio sam potrebu i želju da napišem knjigu čija tema će biti solarna energetika. Sagledavanju ovog aspekta primene OIE posvetio sam mnogo pažnje i vremena u prethodnih nekoliko godina, primenjujući naučna i stručna znanja u realizaciji nekoliko velikih projekata solarnih, agrosolarnih i tzv. hibridnih elektrana u Republici Srbiji. Zato je moja želja bila da svoja iskustva kroz ovu knjigu podelim sa svima kojima je ova oblast predmet interesovanja. Iskustva se baziraju na prostornim (planerskim) aspektima realizacije solarnih elektrana i njihovom uticaju na životnu sredinu.

U duhu predgovora iz knjige posvećene vetroenergetici, ovu knjigu takođe započinjem citatima poznatih, u kojima se ističe značaj primene energije sunca za dobijanje energije.

Autor

FOREWORD

After my previous book, The Spatial Aspects of the Impact of Wind Farms on the Environment (2017, Eng. 2020), the first one dedicated to “green” energy, and due to the expansion in the use of renewable energy sources (RES), I felt the need and desire to write a book on the topic of solar energy. I have devoted much attention and time to examining this aspect of RES application over the past few years, applying scientific and professional knowledge in the implementation of several large solar, agro-solar, and so-called hybrid power plant projects in the Republic of Serbia. Therefore, my desire was to expand my experiences through this book to all those interested in this field. The experiences are based on spatial (planning) aspects of solar power plant implementation and their impact on the environment, which is analyzed through the process of Strategic Environmental Assessment.

In the spirit of the preface from the previous book, which was dedicated to wind energy, I also begin this book with quotes from renowned figures emphasizing the importance of solar energy application for energy production.

The Author

„Sunce održava sav ljudski rod i daje svu ljudsku energiju."

(Nikola Tesla)

"The sun maintains all human life and supplies all human energy"

(Nikola Tesla)

„Treba znati iskoristiti prirodne sile i na taj način dobiti potrebnu energiju. Sunčevi zraci su oblik energije, vetar i morske struje su takođe energija. Koristimo li ih? O, ne! Palimo šume i ugalj, kao što podstanari pale ulazna vrata gazdinjske kuće da bi se ogrejali. Živimo kao divlji doseljenici koji ne shvataju da ova bogatstva pripadaju svima nama."

(Tomas A. Edison)

"We should utilize natural forces and thus get all of our power. Sunshine is a form of energy, and the winds and the tides are manifestations of energy. Do we use them? Oh, no; we burn up wood and coal, as renters burn up the front fence for fuel. We live like squatters, not as if we owned the property."

(Thomas Edison)

„Mi smo kao farmeri koji seku ogradu oko kuće da bi dobili gorivo umesto da koristimo nepresušne prirodne izvore energije – sunce, vetar i plimu… Ja bih svoj novac stavio na sunce i sunčevu energiju. Kakav izvor snage! Nadam se da nećemo čekati da nafta i ugalj nestanu pre nego što se pozabavimo tim."

(Tomas A. Edison)

"We are like tenant farmers, chopping down the fence around our house for fuel, when we should be using nature's inexhaustible sources of energy—sun, wind, and tide.I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait till oil and coal run out before we tackle that.."

(Thomas Edison)

„Pošto nam ponestaje gasa i nafte, moramo se brzo pripremiti za treću promenu, striktno očuvanje i korišćenje uglja i trajnih obnovljivih izvora energije, poput solarne energije."

(Džimi Karter)

"Because we are now running out of gas and oil, we must prepare quickly for a third change--to strict conservation and to the renewed use of coal and to permanent renewable energy sources like solar power."

(Jimmy Carter)

„Upotreba solarne energije ima ogroman potencijal za očuvanje prirodnih resursa i klime, kao i za širu upotrebu obnovljivih izvora energije ako želimo snabdevanje energijom okrenuto ka budućnosti."

(Margareta Vulf)

"The use of solar energy offers huge potential for natural resource and climate protection, and for the expansion of renewable energies on the road to a future-oriented energy supply."

(Margareta Wolf)

„Svaka 24 sata na Zemlju stiže dovoljno sunčeve svetlosti da energijom opskrbi planetu za naredne 24 godine.”

(Marta Maeda)

“Every 24 hours, enough sunlight touches the Earth to provide energy for the entire planet for 24 years.”

(Martha Maeda)

„Imamo taj zgodan fuzioni reaktor na nebu koji se zove sunce – ne moramo ništa da radimo, on radi sam. Izgreva svaki dan.”

(Ilon Mask)

“We have this handy fusion reactor in the sky called the sun, you don’t have to do anything, it just works. It shows up every day.”

(Elon Musk)

„Budućnost će biti zelena ili je neće ni biti.”

(Bob Braun)

“The future will either be green or not at all.“

(Bob Brown)

„Sva energija se na kraju dobija od sunca, a njeno direktno prikupljanje u vidu solarne energije izgleda da je najbolji način za prelazak na obnovljive izvore.”

(Piter Rajv)

“All energy is ultimately derived from the sun, and harvesting it directly through solar power seems to be the best way to transition to renewable energy.“

(Peter Rive)

1. UVOD

Dinamično povećanje broja stanovnika na planeti i razvoj privrede u direktnoj su korelaciji s rastućom potrošnjom energije na globalnom nivou. Ako se ima u vidu briga o životnoj sredini i zabrinutost zbog klimatskih promena, što su aktuelne teme poslednjih decenija, a znajući da je upravo energetski sektor društvena aktivnost koja implicira najveći uticaj na životnu sredinu, klimu i ljudsko zdravlje, ne čudi što su današnji globalni trendovi usmereni na smanjenje prekomerne upotrebe fosilnih goriva i povećanje korišćenja obnovljivih izvora energije.

Obnovljivi izvori energije (OIE) predstavljaju energetske resurse koji se koriste za proizvodnju električne, toplotne i mehaničke energije a čije rezerve se konstantno ili ciklično obnavljaju. Osnovne karakteristike OIE jesu obnovljivost/trajnost, odnosno činjenica da njihova potrošnja ne premašuje brzinu kojom se oni iznova stvaraju u prirodi. Pored toga, njihova prednost u odnosu na korišćenje fosilnih goriva jeste u manjem uticaju na prostor, životnu sredinu i ljudsko zdravlje, kao i smanjena emisija CO_2 u procesu proizvodnje energije, što u „eri održivog razvoja" ima poseban značaj (Josimović, 2017).

Porast globalne potražnje za energijom neutralisao je rast upotrebe OIE. Kao rezultat toga, udeo fosilnih goriva u

1. INTRODUCTION

Dynamic increase in population on the planet and economic development are directly correlated with the growing energy consumption at a global level. Considering the concern for the environment and the apprehension about climate change, which have been prominent topics in recent decades, and knowing that the energy sector is precisely the societal activity that implies the greatest impacts on the environment, climate, and human health, it is not surprising that today's global trends are focused on reducing excessive use of fossil fuels and increasing the use of renewable energy sources.

Renewable energy sources (RES) represent energy resources used for the production of electricity, heat, and mechanical energy, whose reserves are constantly or cyclically replenished. The basic characteristic of RES is that they are renewable/permanent, meaning that their consumption does not exceed the rate at which they are replenished in nature. Additionally, their advantage over the use of fossil fuels lies in their lesser impact on space, the environment, and human health, as well as in the reduced or eliminated CO2 emissions in the energy production process, which holds special significance in the era of sustainable development (Josimović, 2017).

The increase in global energy demand has offset the growth in the use of RES. As a ukupnoj finalnoj potrošnji energije ostao je skoro isti od 2009. OIE su zadovoljili nešto više od 12,6% globalne finalne potražnje za energijom u 2020. godini, što je samo neznatno povećanje u odnosu na 8,7% u 2009. Čak i udeo OIE u finalnoj potražnji za električnom energijom stagnirao je 2020. u poređenju sa 2019. Uprkos rekordnom povećanju kapaciteta obnovljivih izvora energije u 2021. godini, porast globalne potražnje za električnom energijom uglavnom je zadovoljen fosilnim gorivima. Upotreba uglja u proizvodnji električne energije porasla je za 9%, u poređenju s povećanjem proizvodnje iz OIE od 5%. Napredak je takođe bio neujednačen po regionima. Od 2019. godine, od 80 zemalja samo tri – Island, Norveška i Švedska – imale su udeo OIE iznad 50%, a 20 zemalja, uglavnom iz Evrope i Latinske Amerike, zadovoljilo je najmanje četvrtinu svoje ukupne finalne potrošnje energije obnovljivim izvorima (Renewables Global Status Report, 2022).

Rast kapaciteta obnovljivih izvora energije dostigao je rekord svih vremena – veći je 11% u odnosu na 2020. – a proizvodnja je porasla za 6%. Energetski sektor, međutim, predstavlja samo 17% svetske finalne potrošnje energije, znatno ispod ostalih sektora. Grejanje, hlađenje i transport zajedno čine više od 80% finalne potražnje za energijom, ali je njihov udeo u obnovljivim izvorima mnogo manji: 11,2% koristi se za grejanje i hlađenje (uglavnom u stambenim i poslovnim prostorima i industriji) i samo 3,7% za transport.

Nakon pada potražnje za energijom izazvanog pandemijom 2020. godine, svetska ekonomska aktivnost oporavila se 2021. godine, što je rezultiralo povećanjem globalne potražnje za energijom od 4%, kao i rekordnom emisijom CO_2. Samo u Kini

result, the share of fossil fuels in total final energy consumption has remained nearly the same since 2009. RES met slightly more than 12.6% of global final energy demand in 2020, which is only a slight increase from 8.7% in 2009. Even the share of RES in final electricity demand stagnated in 2020 compared to 2019. Despite record increases in renewable energy capacity in 2021, the rise in global electricity demand was mostly met by fossil fuels. For electricity generation, coal use increased by 9%, compared to a 5% increase in production from RES. Moreover, progress was uneven across regions. Since 2019, only 3 out of 80 countries - Iceland, Norway, and Sweden - had a RES share above 50%, and 20 countries, mostly in Europe and Latin America, met at least a quarter of their total final energy consumption from renewable energy sources (Renewables Global Status Report, 2022).

The growth in renewable energy capacity reached an all-time record - 11% higher than in 2020 - and production increased by 6%. However, the energy sector represents only 17% of global final energy consumption, significantly below other sectors. Heating, cooling, and transport together account for over 80% of final energy demand, but their share of renewable sources is much lower, at 11.2% for heating and cooling (mostly used in buildings and industry) and only 3.7% in transport.

After a decline in energy demand caused by the 2020 pandemic, global economic activity rebounded in 2021, resulting in a 4% increase in global energy demand and record CO_2 emissions. In China alone, final energy consumption increased by 36% between 2009 and 2019. Most of finalna potrošnja energije porasla je za 36% između 2009. i 2019. Najveći deo povećanja globalne potražnje za energijom u 2021. činila su fosilna goriva, što je doprinelo najvećem povećanju globalne emisije CO_2 u istoriji, za više od dve milijarde tona. U svetlu pandemije COVID-19 i sve većeg broja dokaza o klimatskim katastrofama, 2021. je bila godina povećanih ambicija. Vlade, korporacije, gradovi i drugi akteri prepoznali su ulogu obnovljivih izvora energije u rešavanju klimatskih promena, zagađenja vazduha i postizanja razvojnih ciljeva. U maju je Međunarodna agencija za energetiku objavila svoj scenario Neto Zero do 2050. godine, koji podržava rastući zamah energetske efikasnosti i ubrzano korišćenje obnovljivih izvora energije i naglašava hitnost okončanja upotrebe fosilnih goriva.

Obnovljiva energija je činila 28,3% globalnog miksa električne energije u 2021. godini, otprilike na nivou iz 2020. godine. Rast korišćenja OIE ublažen je ukupnim porastom potražnje za električnom energijom i uslovima suše koji su u velikoj meri smanjili globalnu proizvodnju hidroenergije. Procena je da se globalna potražnja za energijom povećala 4%, dok je emisija CO_2 porasla za rekordnih 6%, nakon pada od 5% u 2020. godini. Uprkos napretku OIE u energetskom sektoru, porast globalne potražnje za energijom uglavnom je zadovoljen fosilnim gorivima. Najveći uspeh za OIE u 2021. godini ostvaren je u energetskom sektoru. Tokom godine privremenog ekonomskog oporavka, dodato je rekordnih 314,5 GW novih kapaciteta iz OIE, a globalni instalisani kapacitet iz OIE dostigao je 3.146 GW, što je rekordan nivo (Renewables Global Status Report, 2022).

the increase in global energy demand in 2021 was met by fossil fuels, contributing to the largest increase in global CO_2 emissions in history (a 6% increase after a 5% decline) in 2020 - an increase of over 2 billion tons. In the light of COVID-19 and the increasing evidence of climate disasters, 2021 was a year of heightened ambitions. Governments, corporations, cities, and others gave stronger recognition to the role of renewable energy sources in addressing climate change, air pollution, and development goals. In May, the International Energy Agency released its Net Zero by 2050 scenario, supporting the growing momentum for energy efficiency and accelerated use of renewable energy sources and emphasizing the urgency of ending the use of fossil fuels.

Renewable energy accounted for 28.3% of the global electricity mix in 2021, roughly at the level of 2020. The growth in the use of RES was mitigated by an overall increase in electricity demand and drought conditions that significantly reduced global hydropower production. Global energy demand is estimated to have increased by 4%, while CO_2 emissions increased by a record 6%, following a 5% decline in 2020. Despite progress in RES in the energy sector, the increase in global energy demand was mostly met by fossil fuels. The greatest success for RES in 2021 was in the energy sector. During a year of temporary economic recovery, a record 314.5 GW of new RES capacity was added, and global installed RES capacity reached 3,146 GW, a record level (Renewables Global Status Report, 2022).

Najveće rast dostignut je u oblasti korišćenja energije vetra i sunca u vetroelektranama i solarnim elektranama. Ova dva izvora zajedno činila su skoro 90% svih novih OIE. Solarne elektrane proizvele su više od polovine dodatne energije (oko 175 GW), a vetroelektrane još dodatna 102 GW. Pored podrške regulatornih i političkih okvira, brzi pad troškova igrao je ključnu ulogu u porastu broja instalacija. Poređenja radi, samo 26 GW hidroenergetskog kapaciteta pušteno je u rad 2021. godine. (Renewables Global Status Report, 2022).

Najveće zasluge za ovakvo povećanje proizvodnje enegije iz OIE mogu se pripisati razvoju ekološke svesti, uz istovremenu mogućnost ostvarivanja zarade, što je po svemu sudeći idealna kombinacija. Sa ekološkog aspekta, razvoj projekata u oblasti korišćenja OIE važan je iz nekoliko razloga (Josimović, 2017):

- obnovljivi izvori energije imaju vrlo važnu ulogu u smanjenju emisije gasova sa efektom staklene bašte (engl. *GHG – greenhouse gases*), pre svega ugljen-dioksida (CO_2) u atmosferu. Smanjenje emisije CO_2 politika je i Evropske unije i mnogih drugih država u svetu;
- povećanjem udela obnovljivih izvora u proizvodnji energije povećava se energetska održivost sistema. Time se takođe smanjuje zavisnost od uvoza energetskih sirovina i električne energije;
- očekuje se da će obnovljivi izvori energije postati ekonomski konkurentni konvencionalnim izvorima energije u srednjoročnom razdoblju.

Tehnološki razvojni projekti u oblasti korišćenja energije sunca u solarnim elektranama u ekspanziji su, što rezultira gotovo svakodnevnim nalaženjem sve boljih tehničkih rešenja za efikasnije pretvaranje energije sunca u električnu

The largest growth was achieved in the use of wind and solar energy in wind farms and solar power plants. Together, these two sources accounted for almost 90% of all new RES. Solar power plants accounted for more than half of the additions (about 175 GW), with wind farms adding an additional 102 GW. In addition to supportive regulatory and policy frameworks, rapid cost declines played a key role in the increase in installations. For comparison, only 26 GW of hydropower capacity was commissioned in 2021 (Renewables Global Status Report, 2022).

The main credit for this increase in RES energy production can be attributed to the development of environmental awareness alongside the opportunity for profit, which seems like an ideal combination. From an environmental perspective, the development of projects in the field of RES is important for several reasons (Josimović, 2017):

- Renewable energy sources play a very important role in reducing greenhouse gas emissions, primarily carbon dioxide (CO2), into the atmosphere. Reducing CO2 emissions into the atmosphere is the policy of the European Union and many other countries worldwide;
- Increasing the share of renewable energy sources enhances the energy sustainability of the system. It also helps reduce dependence on the import of energy resources and electricity;
- It is expected that renewable energy sources will become economically competitive with conventional energy sources in the medium term.

Technological development projects in the field of solar energy utilization in solar power plants are expanding, resulting in almost daily discoveries of better technical solutions for more efficient conversion i toplotnu energiju. Ovakav tehnološki razvoj, kao i u slučaju vetroelektrana, znači da je za proizvodnju iste količine energije danas potreban manji prostor pod solarnim panelima nego što je to bio slučaj samo nekoliko godina unazad. Ova činjenica je dodatna ekološka korist.

S obzirom na ekspanziju primene energije sunca na globalnom nivou, u ovoj knjizi bavićemo se prostornim aspektom njenog iskorišćenja, i to kroz planiranje velikih solarnih elektrana, odnosno prostorno/teritorijalnim aspektima njihovog uticaja (pozitivnih i negativnih) na kvalitet životne sredine, ne ulazeći pri tome previše u tehnološke i ekonomske aspekte njihove primene. S obzirom na to da se primena OIE uglavnom sagledava u pozitivnom kontekstu u odnosu na kvalitet životne sredine, autor je smatrao korisnim da se, pored isticanja pozitivnih efekata solarne energetike na životnu sredinu, ukaže i na moguće negativne uticaje solarnih elektrana. Na taj način bi se ova oblast sagledala objektivno i celovito, što može poslužiti iznalaženju optimalnijih rešenja u budućem planiranju i razvoju solarne energetike.

U knjizi su korišćena iskustva autora u proceni uticaja planova i projekata na životnu sredinu za više velikih solarnih elektrana, instalisane pojedinačne snage od 100 MW do 800 MW, što predstavlja dobar uzorak za identifikaciju ključnih problema u proceni uticaja, korišćenju metodologije, definisanju odgovarajućih koncepcijskih rešenja za smanjenje uticaja, itd.

of solar energy into electricity and heat energy. Such technological development, as in the case of wind farms, allows for the production of the same amount of energy today with a smaller area under solar panels than was the case just a few years ago. This fact is an additional ecological benefit.

Considering the global expansion of solar energy use, this book will address the spatial aspect of its utilization through the planning of large solar power plants, or spatial/territorial aspects of their impact (both positive and negative) on the quality of the environment. Without delving too much into the technological and economic aspects of their implementation. Since the application of RES is generally viewed in a positive context regarding environmental quality, the author considered it useful to highlight both the positive effects of solar energy on the environment and possible negative impacts of solar power plants. This way, this area would be viewed objectively and comprehensively, which can serve for more optimal solutions in future planning and development of solar energy.

The book draws on the author’s experience in assessing the impact of plans and projects on the environment for several large solar power plants, with individual installed capacities ranging from 100 MW to 800 MW, which provided a good sample for identifying key issues in impact assessment, methodology usage, defining appropriate conceptual solutions for impact reduction, etc.

2. KORIŠĆENJE ENERGIJE SUNCA

2.1. Istorijat korišćenja energije sunca

Energija sunca oduvek je bila na raspolaganju čoveku. Prema tvrdnjama eksperta za solarnu istoriju Džona Perlinga (2004), drevni Grci su počeli da koriste solarnu energiju pre 2.500 godina i od tad su ljudi koristili sunce za svoje potrebe na različite načine. Prema njegovim rečima, do 2000. godine pre nove ere kineski urbanisti su počeli da projektuju gradove sa ulicama koje se pružaju isključivo od istoka ka zapadu kako bi svaki dom mogao da ima deo okrenut prema jugu pri punom sunčevom svetlu. Neolitski kineski graditelji domova zapravo su proizveli većinu tehnika pasivnog solarnog grejanja koje i danas koristimo. Prvo su kućne ulaze okretali prema jugu, kako bi se unutrašnjost domova tokom zime grejala suncem koje pada pod niskim uglom. Da bi leti bilo hladnije u kući, izduživali su krovne strehe kako bi zaštitili otvore i sprečili prodor letnje jare u dom. Ovakva arhitektonska rešenja preuzeli su kasnije, tokom 5. veka pre nove ere, i Grci. Naime, ljudi koji su živeli u drevnoj Grčkoj, prema nalazima arheologa, planirali su i projektovali domove tako da svaki ima pristup sunčevoj svetlosti tokom zime, da bi se njome grejao.

Pretpostavlja se da je jedan od najranijih vidova korišćenja sunčeve svetlosti bio sunčani sat (slika 1).

Prema arheološkim nalazima, najraniji poznati kućni satovi bili su sunčani satovi u starom Egiptu i drevnoj vavilonskoj

2. SOLAR ENERGY USE

2.1. The history of solar use

Solar energy has always been available to humans. According to solar history expert John Perling (2004), ancient Greeks began using solar energy 2500 years ago, and since then, people have been harnessing the power of the Sun in various ways. Perling claims that by 2000 BCE, Chinese urban planners started designing cities with streets running exclusively from east to west so that each home could have a part facing south to capture full sunlight. Neolithic Chinese home builders actually developed many passive solar heating techniques still used today. They first positioned house entrances facing south to heat the interiors with low-angle winter sun. To keep homes cooler in summer, they extended roof overhangs to shade openings and block hot summer sunlight from entering the house. These architectural solutions were later adopted during the 5th century BCE by the Greeks. Indeed, people living in ancient Greece, according to archaeologists' findings, planned and designed homes to provide access to sunlight during winter to warm the homes.

It is assumed that one of the earliest known uses of solar light was in the form of a sundial (Figure 1).

The earliest known domestic timepieces, from archaeological finds, are sundials in ancient Egypt and ancient Babylonian

Slika 1. Sunčani sat – 1500 p.n.e. (izvor: green-the-world.net)
Figure 1. Sundial – 1,500 BCE. (Source: green-the-world.net)

astronomiji. Drevni analematski sunčani satovi iz iste epohe (oko 1500. godine p.n.e.) i njihov prototip otkriveni su na teritoriji savremene Rusije (Vodolazhskaya et al, 2014). Ljudi su verovatno određivali vreme na osnovu dužine senke još i ranije, ali je to teško proveriti. Otprilike 700. godine p.n.e, Stari zavet opisuje sunčani sat — „sunčanik Ahazov" pominje se u Knjizi proroka Isaije 38:8 i Drugoj knjizi o carevima 20:9, što je verovatno najraniji izveštaj o sunčanom satu koji se može naći bilo gde u istoriji — koji je verovatno bio egipatski ili vavilonski (Depuydt, 1998). Sunčani satovi su postojali u Kini od davnina, ali se o njihovoj istoriji zna vrlo malo. Poznato je da su stari Kinezi razvili oblik sunčanih satova 800. godine p.n.e, a sunčani satovi su do 1000. godine nove ere evoluirali u veoma složene mehanizme. U vreme dinastije Song (1000–1400. n.e.) neki sunčani časovnici sadržali su i kompas (Needham, 1959). Kasnije su Stari Grci razvili mnoge principe i oblike sunčanog sata. Veruje se da je sunčane satove u Grčku doneo Anaksimandar iz Mileta (560. p.n.e.). Grci su bili u dobroj poziciji da razviju nauku o

astronomy. Ancient analemmatic sundials from the same era (around 1500 BCE) and their prototype were discovered in what is now modern-day Russia (Vodolazhskaya et al., 2014). People may have determined time by the length of shadows even earlier, but this is difficult to verify. Around 700 BCE, the Old Testament describes a sundial — "Ahaz's sundial" mentioned in Isaiah 38:8 and 2 Kings 20:9 (probably the earliest report of a sundial found anywhere in history) — which was likely of Egyptian or Babylonian design (Depuydt, 1998). Sundials existed in China from ancient times, but very little is known about their history. It is known that ancient Chinese developed a form of sundials in 800 BCE, and sundials eventually evolved into very sophisticated clocks by 1000 CE, sometime in the Song Dynasty (1000-1400 CE), a compass would sometimes also be constructed on the sundial (Needham, 1959). Later, the ancient Greeks developed many principles and forms of sundials. It is believed that Anaximander of Miletus (560 BCE) introduced sundials to Greece. The Greeks were in a good position to sunčanim satovima, pošto su poznavali geometriju. Smatra se da je matematičar i astronom Teodosije iz Bitinije (oko 160. p.n.e.) izumeo univerzalni sunčani sat koji može da se koristi bilo gde na Zemlji.

U teoriji, ljudi su solarnu energiju intenzivnije koristili počev od 7. veka pre nove ere, kad su sunčevu svetlost koristili za paljenje vatre pomoću materijala kojima su skupljali i usmeravali sunčevo zračenje. Arhimedov (287–212. p.n.e.) izum poznat kao Arhimedovi toplotni zraci, jedan je od njegovih najinteresantnijih izuma koji je našao primenu u vojsci Sirakuze. Arhimed je došao do saznanja o žarištima konkavnih ogledala, tačnije poliranog metala koje se tada koristilo sa istom namenom. Princip se zasnivao na postavljanju dva ogledala, od kojih se odbija sunčeva svetlost i sva toplota koncentriše u jednoj tački (slika 2). Zahvaljujući tome, neprijateljski brodovi su se mogli spaljivati na udaljenosti od pedesetak metara (Tomić, 2016).

develop the science of sundials, as they developed the science of geometry. Theodosius of Bithynia (around 160 BCE), a mathematician and an astronomer, is said to have invented a universal sundial that could be used anywhere on Earth.

In theory, people used solar energy more intensively as early as the 7th century BCE when history tells us people used sunlight to ignite fires using materials to concentrate solar radiation. Archimedes’ (287 BCE – 212 BCE) invention known as Archimedes’ heat rays is one of his most interesting inventions used in the Syracuse military. Archimedes discovered the principle of the focal point of concave mirrors, namely polished metal used for the same purpose at that time. The principle is based on placing two mirrors from which sunlight is reflected, and all heat is concentrated at one point (Figure 2). Thanks to this, enemy ships could be burned at a distance of about fifty meters (Tomić, 2016).

Slika 2. Arhimedovi toplotni zraci (izvor: sciencephoto.com)

Figure 2. Archimedes’ heat rays (Source: sciencephoto.com)

Grčki filozof Sokrat (470–399. p.n.e.) posvetio se izgradnji čitavog grada oko solarne energije. Verovao je da će građevinama, ako ih postavi na određeni način, obezbediti pristup pasivnom solarnom sistemu (Hugh, 1911). Ovakav način strukturiranja i pozicioniranja hladi dom leti a greje zimi.

Grci nisu bili jedina civilizacija koja je znala za prednosti pasivne solarne energije. Kasnije su Rimljani poboljšali tehnologiju korišćenja sunčeve energije zatvaranjem otvora na građevinama staklom kako bi zadržali toplotu u građevini. Pored toga, zahvaljujući solarnom grejanju rimska kupatila su bila izuzetno popularna u to vreme (slika 3).

Kroz proces koji se naziva hipokaust, vruć vazduh je cirkulisao u šupljem prostoru ispod podova. Kupatila su imala podignute podove i šuplje zidne ploče u kojima se vruć vazduh mešao s toplom vodom i stvaralo parno okruženje. Rimljani su takođe stvorili solarne staklenike, u kojima su se pokrivači koristili za zadržavanje toplote i održavanje idealne temperature unutrašnjeg okruženja za sazrevanje plodova.

The Greek philosopher, Socrates (470 BCE – 399 BCE), dedicated himself to building an entire city around solar energy. He believed that if structures were built in a certain way, they would have access to a passive solar system (Hugh, 1911).This way of structuring and positioning can keep homes cool in summer and warm in winter.

The Greeks were not the only civilization to learn the advantages of passive solar energy. Later, the Romans improved solar energy usage by adding glass to openings to trap heat from the inside. In addition, solar heating made Roman baths extremely popular at that time (Figure 3).

Through a process called hypocaust, hot air circulated in the hollow space beneath the floors. The baths had raised floors and hollow wall plates for mixing hot air with warm water and creating a steamy environment. The Romans also created solar greenhouses, where covers were used to retain heat and maintain the internal environment perfect for ripening produce.

Slika 3. Ostaci rimskog kupatila (izvor: adtsolar.com)

Figure 3. Remains of a Roman bath (Source: www.adtsolar.com)

Rimljani su usvojili genijalne grčke sisteme solarnog grejanja. Do 550. godine nove ere, vlasnici kuća su koristili sunčevu svetlost za grejanje i osvetljenje, ali i sunčane satove. Sunčeva svetlost je bila toliko važna za Rimljane, da je pravo na pristup solarnoj energiji ušlo i u Justinijanov zakonik. Prema pravu solarne službenosti, komšije nisu smele jedne drugima da blokiraju sunčevu svetlost. Sudija je odlučivao koliko sunčeve svetlosti vlasnik kuće može razumno očekivati, a koliko sunčeve svetlosti komšija sme razumno da blokira (solartribune.com/the-history-of-solar-energy).

Početak nove ere doneo je sunce i u javna kupatila i domove. Građevine na jugu Rima imale su ogromne prozore kako bi se prostorije grejale solarnom energijom. *Sunčane sobe* su bile toliko česte da je u 6. veku car Justinijan proklamovao „pravo na sunce" kako bi ono bilo dostupno svima.

Kasnije, u 13. veku, preci Pueblo Indijanaca poznati kao Anasazi pravili su nastambe na liticama okrenutim prema jugu kako bi uhvatili sunčevu toplotu tokom hladnih zimskih meseci. Američki domoroci iz Mesa Verde takođe su shvatali značaj toplote sunca pa su svoje naseobine klesali u stene okrenute prema jugu da bi „hvatali" zimske zrake (slika 4).

Još jedna rana upotreba solarne energije koja je i danas popularna bio je koncept „sobe za sunčanje". Ove sunčane sobe koristile su masivne prozore za usmeravanje sunčeve svetlosti u jedno koncentrisano područje.

Preskačemo nekoliko stotina godina i dolazimo do 18. i 19. veka, kad su istraživači i naučnici ostvarili ozbiljniji napredak u korišćenju energije sunca i uspeli da

The Romans adopted ingenious Greek solar heating systems. By 550 CE, homeowners were using sunlight for heating and lighting, as well as sundials. Sunlight was so important to the Romans that the right to solar access was actually enshrined in Justinian's Code. According to the law, solar easements prevented neighbours from blocking sunlight. The judge decided how much sunlight the homeowner could reasonably expect to enjoy and how much sunlight the neighbour could reasonably block (solartribune.com/the-history-of-solar-energy).

The beginning of the new era brought the Sun into public baths and homes. Buildings in Rome's south had huge windows to heat rooms with solar energy. Solar rooms were so common that in the sixth century, Emperor Justinian proclaimed the "right to the Sun" to make it available to everyone.

In the 1200s CE, the ancestors of the Pueblo Indians known as the Anasazi lived in south-facing cliff dwellings to capture solar warmth during cold winter months. Native Americans in Mesa Verde also understood the importance of solar heat, so they built their cliff-carved settlements facing south to "catch" winter rays (Figure 4).

Another early use of solar energy that remains popular today was the concept of "sunrooms" in buildings. These solar rooms used massive windows to direct sunlight into a concentrated area.

Skipping several hundred years, we come to the 18th and 19th centuries when researchers and scientists made more significant progress in using solar energy and managed to use sunlight to power steam engines for long journeys. They also

Slika 4. Mesa Verde, dom seoskog stanovništva Anasaza – 13. vek (izvor: SHUTTERSTOCK)

Figure 4. Mesa Verde, home to the Anasazi rural population – 13th century (Source: SHUTTERSTOCK)

koriste sunčevu svetlost za napajanje parnih mašina za duga putovanja. Takođe su koristili snagu sunca za proizvodnju parobroda na solarni pogon.

Jasno je da je čak i hiljadama godina pre ere solarnih panela koncept manipulisanja snagom sunca bio uobičajena praksa. Od pumpe za vodu, preko instrumenta za merenje zračenja bolometra, do određenih teorijskih otkrića – utiran je put američkom inženjeru Čarlsu Fritsu da 1883. godine od selena kao poluprovodnika napravi ćelije na sunčevu energiju. Godinu dana kasnije prvi niz solarnih ćelija postavljen je na krovu jedne zgrade u Njujorku. Njihova efikasnost pretvaranja, međutim, bila je niža od 1%, ali je svakako poslužila kao praktični pokazatelj da je konverzija sunčevih zraka u električnu energiju posredstvom čvrstog materijala moguća.

Godine 1921. Albert Ajnštajn je dobio Nobelovu nagradu za fiziku za svoju teoriju o fotoelektričnom efektu. Zapravo, ovaj

harnessed the power of the sun to produce solar-powered steamships.

Clearly, even thousands of years before the era of solar panels, the concept of harnessing solar power was a common practice. From water pumps to radiation measuring instruments, to certain theoretical discoveries – all paved the way for American engineer Charles Fritts to create solar cells using selenium as a semiconductor in 1883. A year later, the first solar array was installed on a building's roof in New York. Its conversion efficiency was, however, less than 1 percent, but it certainly served as a practical indicator that converting solar rays into electrical energy through solid material was possible.

In 1921, Albert Einstein was awarded the Nobel Prize in Physics for his theory of the photoelectric effect. In fact, this phenomenon had been observed earlier (as far back as 1839), but Einstein's findings made it useful to scientists. Darrell Chapin, Calvin Fuller, and Gerald Pearson developed a solar power plant in fenomen je primećen i ranije (daleke 1839. godine), ali je zahvaljujući Ajnštajnovim nalazima postao koristan naučnicima. Godine 1954. Daril Čejpin, Kalvin Fuler i Džerald Pirson razvili su solarnu elektranu koja je proizvodila dovoljno energije za napajanje električnih uređaja u svakodnevnoj upotrebi. Efikasnost je najpre povećana na 4%, a zatim i na 11%. Iza projekta prve komercijalne poslovne zgrade pasivnog dizajna i s grejanjem „na sunce", izgrađene u drugoj polovini 20. veka, stoji arhitekta Frenk Bridžers. Korporacija *Hofman elektroniks* podigla je efikasnost solarnih ćelija na 14% 1960. godine. Tri godine kasnije Japan je na svetioniku postavio elektranu od 242 W, najveću toga vremena. Ćeliju po ćeliju, 1970. proizvodnja iz solarnih elektrana premašila je 500 KW. Prva solarna elektrana snage 1 MW izgrađena je 1982. godine u Kaliforniji, dok su pionirski letački poduhvat avionom na solarni pogon *Ikar* preduzeli Nemci 1996. godine. Krila i rep *Ikara* sadržali su 3.000 superefikasnih solarnih ćelija. Kumulativni kapacitet fotovoltaika dostigao je „jubilarnih" 1.000 MW 1999. godine. Krajem 2019. godine popeo se na 629 GW. Dakle, od neefikasnih ćelija iz 1883. godine do udela od 3% u globalnom energetskom miksu u 2019. godine dug je put. Međunarodna egencija za energiju (IEA) prognozira da će rast solarne energije do 2050. godine obezbediti 4,7 „sunčanih" teravata. Solarni paneli postaju sve efikasniji, pristupačniji i tanji, a u doba globalne borbe protiv klimatskih promena i sve poželjniji izvor energije (https://nationalgeographic.rs/proizvedi-energiju/a27928/Koriscenje-energije-sunca-kroz-istoriju.htm).

1954 capable of producing enough energy to power everyday electrical devices. Efficiency was first increased to 4 percent and then to 11 percent. Behind the project of the first commercial passive design business building with solar heating, built in the second half of the twentieth century, stands architect Frank Bridgers. Hoffman Electronics Corporation raised the efficiency of solar cells to 14 percent in 1960. Three years later, Japan installed a 242W power plant on a lighthouse, the largest of that time. Cell by cell, in 1970, solar power production exceeded 500KW from a solar power plant. The first power plant, with a capacity of 1MW, was built in California in 1982, while the pioneer flying feat by a solar-powered aircraft "Icarus" was undertaken by Germans in 1996. The wings and tail of "Icarus" were covered with 3,000 super-efficient solar cells. Cell by cell, in 1970, solar power production exceeded 500KW from a solar power plant. The first power plant, with a capacity of 1MW, was built in California in 1982, while the pioneer flying feat by a solar-powered aircraft "Icarus" was undertaken by Germans in 1996. The cumulative capacity of photovoltaics marked the "jubilee" of 1,000MW in 1999. By the end of 2019, it had risen to 629GW. Therefore, from inefficient cells in 1883 to a 3 percent share in the global energy mix in 2019, it was a long way. The International Energy Agency (IEA) forecasts that solar energy growth will provide 4.7 "sunny" terawatts by 2050. Solar panels are becoming more efficient, affordable, and thinner, and in the age of the global fight against climate change, they are becoming an increasingly desirable source of energy (https://nationalgeographic.rs/proizvedi-energiju/a27928/Koriscenje-energije-sunca-kroz-istoriju.htm).

2.2. Tendencije u korišćenju energije sunca

2.2.1. Korišćenje energije sunca na globalnom nivou

Tokom proteklih nekoliko decenija klimatska kriza i ciljevi održivog razvoja UN bili su istaknuti pokretači prelaska na obnovljive izvore energije. Posmatrajući samo period nakon pandemije COVID-19, svet je s nadom očekivao „zeleni" oporavak zbog rekordnog povećanja globalnog instaliranog kapaciteta obnovljive energije i rekordne investicije u obnovljive izvore energije, povećanja udela solarne energija i energija vetra, više od 135 zemalja koje imaju za cilj nultu emisiju gasova sa efektom staklene bašte neto i objavljivanja prvog neto nultog scenarija Međunarodne agencije za energiju, u kom se spominje potreba ukidanja fosilnih goriva i nudi zemljama plan koji bi trebalo da slede.

Ipak, globalna energetska tranzicija otežano se dešava. Globalni geopolitički potresi nakon pandemije i rast cena roba poremetili su lance snabdevanja obnovljivim izvorima energije i odložili razvoj projekata. Takođe, oporavak ekonomske aktivnosti doveo je do povećanja globalne potražnje za energijom od otprilike 4%, od čega je veliki deo bio zadovoljen fosilnim gorivima, što je rezultiralo rekordnom emisijom CO_2. Porast cena energenata u drugoj polovini 2022. godine doprineo je globalnoj energetskoj krizi.

Najbolji rezultati za 2022. godinu u prelasku na obnovljive izvore energije ostvareni su u energetskom sektoru, dok je napredak u sektoru transporta spor. Takođe, veliki problem predstavljaju domaćinstva i energija koja se koristi za grejanje i hlađenje.

2.2. Trends in Solar Energy Usage

2.2.1. Global Level Solar Energy Usage

Over the past few decades, the climate crisis and UN Sustainable Development Goals have been prominent drivers of the transition to renewable energy sources. Looking only at the period after the COVID-19 pandemic, the world has hoped for a "green" recovery due to: record increases in global installed renewable energy capacity and record investments in renewable energy sources; increases in the share of solar and wind energy; more than 135 countries having net-zero greenhouse gas emission targets; the release of the first net-zero scenario by the International Energy Agency, mentioning the need to phase out fossil fuels and offering a plan for countries to follow.

However, the global energy transition is happening slowly. Global geopolitical upheavals after the pandemic and rising commodity prices have disrupted renewable energy supply chains and delayed project development. Additionally, the economic activity recovery has led to about a 4% increase in global energy demand, much of which was met by fossil fuels, resulting in record carbon dioxide (CO2) emissions. Rising energy prices in the latter half of 2022 contributed to a global energy crisis.

The best results for 2022 in transitioning to renewable energy were achieved in the energy sector, while progress in the transport sector was slow. Household heating and cooling energy usage also pose significant problems.

Solarna energija i energija vetra čine oko 90% svih novih obnovljivih izvora energije, čime su ostvarili najveći uspeh. Po prvi put ovi izvori daju više od 10% svetske električne energije. Iako to zvuči ohrabrujuće, kako bismo ostali na putu ka neto nultoj emisiji do 2050. godine, potrebno je utrostručiti intenzitet energetske tranzicije. Štaviše, potrebno je prepoloviti globalnu emisiju do 2030. godine, za šta bi sve industrije koje koriste energiju za osvetljenje, proizvodnju, transport, kao i za grejanje i hlađenje, morale da pređu na energiju iz obnovljivih izvora. Solarna energija je efektivno beskonačna i može se proizvesti u bilo kom trenutku kad sunčeva svetlost dospe do tla na bilo kom delu planete Zemlje. Zbog toga upotreba solarne energije raste širom sveta. Izračunato je da su fotonaponski solarni nizovi do kraja 2021. obezbedili oko 5% svetske električne energije – mali procenat, ali u porastu. Stručnjaci procenjuju da su zemlje sveta instalirale kapacitete za proizvodnju između 133 i 175 GW nove solarne energije 2021. godine, a očekuje se još 200 GW do kraja 2022. Deset vodećih zemalja po proizvodnji solarne energije jesu (REN21, 2022):

Solar and wind energy account for about 90% of all new renewable energy sources, achieving the greatest success. For the first time, these sources provide more than 10% of the world's electricity. Although this sounds encouraging, to maintain the path to achieving net-zero emissions by 2050, the intensity of the energy transition needs to triple. Moreover, by 2030, global emissions need to be halved, for which all energy-using industries including lighting, manufacturing, transportation, as well as heating and cooling, must switch to energy derived from renewable sources. Solar energy is effectively infinite in supply and can be produced at any time when sunlight reaches the ground anywhere on the planet. Therefore, the use of solar energy is growing worldwide. It is estimated that photovoltaic solar arrays provided about 5% of the world's electricity by the end of 2021 – a small percentage but growing. Experts estimate that countries installed between 133 and 175 gigawatts (GW) of new solar energy in 2021, and another 200 GW is expected to be installed by the end of 2022. The top ten countries in solar energy production are (REN21, 2022):

1. Kina / China – 306.973 MW
2. Sjedinjene Američke Države / United States – 95.209 MW
3. Japan / Japan – 74.191 MW
4. Nemačka / Germany – 58.461 MW
5. Indija / India – 49.684 MW
6. Italija / Italy – 22.698 MW
7. Australija / Australia – 19.076 MW
8. Južna Koreja / South Korea – 18.161 MW
9. Vijetnam / Vietnam – 16.660 MW
10. Španija / Spain – 15.952 MW

Upotreba solarne energije širom sveta uveliko varira od zemlje do zemlje, pri čemu prvih 10 zemalja čini približno 74% fotonaponskog tržišta. Od 2021. Kina ima najveći kapacitet solarne energije na svetu,

Usage of solar energy varies widely from country to country, with the top 10 countries representing approximately 74% of the photovoltaic market. Since 2021, China has had the largest solar energy capacity od 306.973 MW, što daje otprilike 4,8%–6% ukupne potrošnje energije u zemlji. Slede Sjedinjene Američke Države sa 95.209 MW i Japan sa 74.191 MW.

Ukupan kapacitet, međutim, samo je jedan od načina posmatranja solarne proizvodnje. Drugi metod da se ispita prodiranje solarne energije jeste procenat ukupne potrošnje energije po zemlji koji dolazi iz solarnih instalacija.

Top 10 zemalja s najvećim procentom prodiranja solarne energije (2021 IEA):

in the world at 306,973 megawatts (MW), which accounts for approximately 4.8%-6% of the country's total energy consumption. Following China are the United States with 95,209 MW and Japan with 74,191 MW.

However, total capacity is just one way to look at solar production. Another method is to examine the penetration of solar energy, which is the percentage of each country's total energy consumption that comes from its solar installations.

Top 10 countries with the highest penetration of solar energy (2021 IEA):

1. Australija / Australia — 15,5%
2. Španija / Spain — 14,2%
3. Grčka / Greece — 13,6%
4. Honduras / Honduras — 12,9%
5. Holandija / Netherlands — 11,8%
6. Čile / Chile — 10,9%
7. Nemačka / Germany — 10,9%
8. Japan / Japan — 9,4%
9. Italija / Italy— 9,3%
10. Izrael / Israel— 8,9%

Tabela 1. Instalisani solarni kapaciteti po zemljama za period 2017–2021 (izvor: World Population Review)

Table 1. Installed solar capacities by country for the period 2017-2021(Source: World Population Review)

Država / Country	Solarni kapacioteti / Solar capacity 2021 (MW)	Zbirno/ Added 2020	Total 2020	2019	2018	2017
Kina / China	306,973	53,009	253,964	204,971	175,262	130,832
Sjedinjene Američke Države / United States	95,209	19,647	75,562	60,826	51,570	43,115
Japan / Japan	74,191	4,427	69,764	63,192	56,162	49,500
Nemačka / Germany	58,461	4,740	53,721	48,914	45,158	42,293
Indija / India	49,684	10,299	39,385	35,203	27,453	18,252
Italija / Italy	22,698	1,042	21,656	20,871	20,114	19,688
Australija / Australia	19,076	1,732	17,344	12,969	8,625	7,354
Južna Koreja / South Korea	18,161	3,586	14,575	11,952	8,099	5,835
Vijetnam / Vietnam	16,660		16,660	4,993	105	8
Španija / Spain	15,952	3,363	12,589	11,143	7,068	7,027
Francuska / France	14,718	2,687	12,031	10,817	9,672	8,610

Država / Country	Solarni kapacioteti / Solar capacity 2021 (MW)	Zbirno/ Added 2020	Total 2020	2019	2018	2017
Holandija / Netherlands	14,249	3,299	10,950	7,226	4,608	2,911
Ujedinjeno Kraljevstvo / United Kingdom	13,689	227	13,462	13,346	13,073	12,760
Brazil / Brazil	13,055	5,176	7,879	4,613	2,435	1,207
Ukrajna / Ukraine	8,062	731	7,331	5,936	2,003	1,200
Turska / Turkey	7,817	1,149	6,668	5,996	5,064	3,422
Tajvan / Taiwan	7,700	1,883	5,817	4,150	2,738	1,768
Meksiko / Mexico	7,040	1,877	5,163	4,440	2,555	1,126
Belgija / Belgium	6,585	1,010	5,575	4,637	4,000	3,621
Poljska / Poland	6,257	2,302	3,955	1,539	562	287
Južna Afrika / South Africa	6,221	231	5,990	4,905	4,801	3,447
Čile / Chile	4,468	1,263	3,205	2,654	2,137	1,809
Kanada / Canada	3,630	288	3,342	3,327	3,095	2,932
Grčka / Greece	3,530	242	3,288	2,834	2,652	2,606
Švajcarska / Switzerland	3,449	476	2,973	2,498	2,173	1,906
Tajland / Thailand	3,049	61	2,988	2,988	2,967	2,702
Kazakstan / Kazakhstan	2,834	1,115	1,719	1,150	490	175
Ujedinjeni arapski Emirati / United Arab Emirates	2,705	399	2,306	1,918	598	355
Austija / Austria	2,692	649	2,043	1,702	1,455	1,269
Izrael / Israel	2,555	83	2,472	2,056	1,291	988
Madjarska / Hungary	2,131		2,131	1,400	728	344
Češka Republika / Czech Republic	2,119	-4	2,123	2,086	2,075	2,070
Portugal / Portugal	1,801	701	1,100	901	667	579
Malezija / Malaysia	1,787	304	1,483	894	545	394
Egipat / Egypt	1,675		1,675	1,647	764	180
Rusija / Russia	1,661	233	1,428	1,276	535	225
Švedska / Sweden	1,577	470	1,107	714	428	244
Danska / Denmark	1,540	236	1,304	1,080	988	906
Jordan / Jordan	1,521	73	1,448	1,186	700	397
Rumunija / Romania	1,398	15	1,383	1,398	1,386	1,374
Filipini / Philippines	1,370	312	1,058	982	917	908
Bugarska / Bulgaria	1,186	89	1,097	1,048	1,033	1,036
Pakistan / Pakistan	1,083	223	860	763	679	655
Argentina / Argentina	1,071	307	764	442	191	9
Maroko / Morocco	774	40	734	734	734	204
Slovačka / Slovakia	535		535	590	472	528

Država / Country	Solarni kapacioteti / Solar capacity 2021 (MW)	Zbirno/ Added 2020	Total 2020	2019	2018	2017
Honduras / Honduras	514		514	514	514	454
Porto Riko / Puerto Rico	491	107	384	336	305	302
Dominikanska Republika / Dominican Republic	490	104	386	315	205	106
El Salvador / El Salvador	478		478	403	198	121
Panama / Panama	465	223	242	222	210	147
Iran / Iran	456	26	430	346	286	184
Alžir / Algeria	448		448	448	448	425
Saudijska Arabija / Saudi Arabia	439	330	109	109	84	34
Šri Lanka / Sri Lanka	434	63	371	285	185	131
Singapor/ Singapore	433	97	336	276	161	116
Kambodža/ Cambodia	428	113	315	124	29	29
Estonija / Estonia	414	206	208	121	32	15
Finska / Finland	404	86	318	222	140	82
Slovenija / Slovenia	367	-3	370	278	247	247
Litvanija / Lithuania	338	90	248	133	92	78
Peru / Peru	336	1	335	335	324	298
Bangladeš / Bangladesh	329	45	284	239	201	185
Kipar / Cyprus	316	87	229	151	118	110
Belorusija / Belarus	269	109	160	154	154	80
Urugvaj / Uruguay	258		258	254	248	243
Jemen / Yemen	253		253	250	250	100
Kuba / Cuba	246	29	217	159	128	65
Senegal / Senegal	238	67	171	171	148	107
Norveška / Norway	225	65	160	120	68	45
Reunion / Reunion	217	12	205	191	190	188
Indonezija / Indonesia	211	26	185	155	65	98
Luksemburg / Luxembourg	209	22	187	160	131	128
Malta / Malta	196	8	188	155	132	112
Kolumbija /Colombia	184	98	86	26	13	11
Jermenija / Armenia	183	88	95	50	17	2
Bolivija / Bolivia	170	50	120	120	70	8
Kenija / Kenya	147	41	106	106	105	38
Novi Zeland / New Zealand	146	4	142	116	90	70
Namibija / Namibia	145		145	145	93	75
Malavi / Malawi	142	60	82	80	26	19

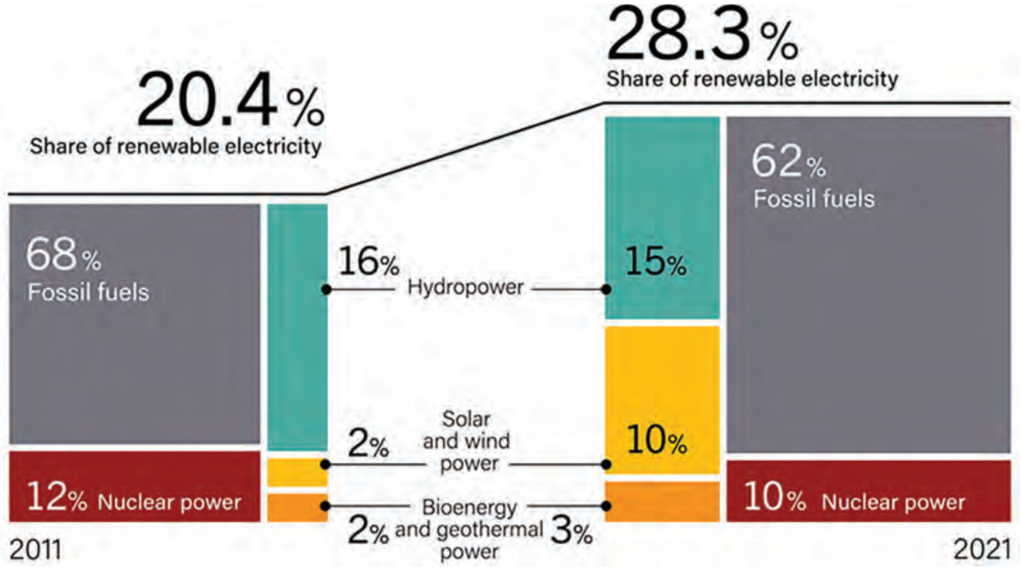
Država / Country	Solarni kapacioteti / Solar capacity 2021 (MW)	Zbirno/ Added 2020	Total 2020	2019	2018	2017
Oman / Oman	138	26	112	9	8	8
Sudan / Sudan	136	19	117	80	59	36
Irska / Ireland	136	43	93	58	32	17
Palestina / Palestine	117		117	82	40	35
Hrvatska / Croatia	109		109	85	68	60
Gana / Ghana	108		108	85	78	47
Uzbekistan / Uzbekistan	104	100	4	4	4	3
Gvatamala / Guatemala	101		101	101	101	99
Mali / Mali	100	30	70	19	19	19
Zambija / Zambia	96		96	96	1	
Tunis / Tunisia	95		95	80	64	47
Severna Makedonija North Macedonia	94		94	26	21	17
Nepal / Nepal	93	26	67	51	52	54
Kuvajt /Kuwait	93		93	93	43	32
Jamajka / Jamaica	93		93	93	56	56
Uganda / Uganda	92	5	87	77	67	44
Mongolija / Mongolia	90		90	89	64	48
Mauritanija/ Mauritania	88		88	88	87	35
Gvadelupe / Guadeloupe	86	1	85	81	70	70
Mauricijus / Mauritius	83		83	83	67	29
Mijanmar / Myanmar	80	-4	84	88	48	44
Nova Kaledonija / New Caledonia	80		80	62	29	26
Liban / Lebanon	79		79	79	58	35
Martinik /Martinique	78	2	76	76	71	68
Kosta Rika / Costa Rica	74	17	57	48	28	28
Burkina Faso / Burkina Faso	62		62	62	62	47
Togo /Togo	56	50	6	5	4	3
Mozambik / Mozambique	55		55	55	55	15
Fransuska Gvineja / French Guiana	55		55	47	47	47
Severna Koreja / North Korea	52	10	42	42	38	35
Srbija / Serbia	52	21	31	23	21	18
Barbados /Barbados	50		50	35	22	21
Azarbejdžan / Azerbaijan	43	15	28	35	35	28
Francuska Polinezija French Polynesia	41		41	41	37	35
Ruanda / Rwanda	38		38	38	38	28
Irak / Iraq	37		37	37	37	37
Gvam / Guam	35		35	35	35	35
Laos / Laos	34		34	34	34	8
Nigerija / Nigeria	33	5	28	28	19	19

Država / Country	Solarni kapacioteti / Solar capacity 2021 (MW)	Zbirno/ Added 2020	Total 2020	2019	2018	2017
Madagaskar / Madagascar	33		33	33	33	13
Afganistan / Afghanistan	31		31	31	22	22
Maldivi / Maldives	31	4	27	21	16	11
Zimbabve / Zimbabwe	30	12	18	16	11	6
Ekvador / Ecuador	28		28	28	27	26
Niger / Niger	27		27	27	27	9
Tanzanija / Tanzania	24		24	24	26	22
Somalija / Somalia	24	8	16	7	7	7
Eritrea / Eritrea	24	2	22	20	18	10
Albanija / Albania	22	5	17	14	1	1
Etijopija / Ethiopia	21	1	20	12	12	12
DR Kongo / DR Congo	20		20	20	20	5
Majot / Mayotte	18		18	15	15	15
Nikaragva / Nicaragua	16		16	16	14	14
Kameron / Cameroon	14		14	14	14	12
Samoa / Samoa	14		14	14	14	14
Kajmanska Ostrva / Cayman Islands	14	1	13	11	10	9
Angola / Angola	13		13	13	13	13
Obala Slonovače / Ivory Coast	13		13	13	13	8
Gineja / Guinea	13		13	13	13	13
Kurasao / Curacao	13		13	12	12	11
Antigva i Barbuda/ Antigua and Barbuda	13		13	9	9	4
Bahrein / Bahrain	11	1	10	9	6	6
Esvatini / Eswatini	11	10	1	1	1	1
Fidži / Fiji	10		10	10	9	7
Surinam / Suriname	9		9	9	9	8
Sejšeli / Seychelles	9	5	4	4	4	3
Moldavija / Moldova	8	4	4	5	3	2
Litvanija / Latvia	8	3	5	3	2	1
Gvajana / Guyana	8		8	8	6	3
Crna Gora / Montenegro	7	1	6	5	4	3
Belize / Belize	7		7	6	4	4
Island / Iceland	7		7	7	5	4
Libija / Libya	6	1	5	5	5	5
Bocvana / Botswana	6		6	6	4	3
Tonga / Tonga	6		6	6	6	6
Aruba / Aruba	6		6	6	6	6
Venecuela / Venezuela	5		5	5	4	5
Burundi / Burundi	5		5	5	5	5
Katar / Qatar	5		5	5	5	5
Bruneji / Brunei	5	4	1	1	1	1
Američka Samoa / American Samoa	5		5	5	5	4
Kukova Ostva / Cook Islands	5		5	5	5	3

Država / Country	Solarni kapacioteti / Solar capacity 2021 (MW)	Zbirno/ Added 2020	Total 2020	2019	2018	2017
Sijera Lion / Sierra Leone	4		4	4	4	4
Trinidad i Tobago / Trinidad and Tobago	4		4	4	4	4
Vanuatu / Vanuatu	4		4	4	4	3
Sveta Lucija / Saint Lucia	4		4	4	4	1
Grenada / Grenada	4		4	3	3	2
Andora / Andorra	4	1	3	2	1	
Benin / Benin	3		3	3	3	3
Haiti / Haiti	3		3	3	3	3
Papa Nova Gvineja / Papua New Guinea	3		3	3	1	1
Liberija / Liberia	3		3	3	3	2
Solomonova ostrva / Solomon Islands	3		3	3	3	3
Kiribati / Kiribati	3		3	3	3	3
Sirija / Syria	2		2	2	1	
Gambija / Gambia	2		2	2	2	2
Bahami / Bahamas	2		2	2	1	1
Mikronezija / Micronesia	2		2	2	2	1
Sveti Vinsent i Grenadini / Saint Vincent and the Grenadines	2		2	2	1	1
Sveti Kits i Nevis / Saint Kitts and Nevis	2		2	2	2	2
Maršalska ostrva / Marshall Islands	2		2	2	2	2
Palau / Palau	2		2	2	2	1
Angvila / Anguilla	2		2	2	1	2
Nauru / Nauru	2		2	2	1	1
Tuvalu / Tuvalu	2		2	2	2	2
Čad / Chad	1		1			
Južni Sudan / South Sudan	1		1	1	1	
Republika Kongo/ Republic of the Congo	1		1	1	1	1
Gruzija / Georgia	1		1	1		
Gabon / Gabon	1		1	1	1	1
Sveti Martin / Saint Martin	1		1	1		
Monserat / Montserrat	1	1				
Nijue / Niue	1		1	1		
Tokelau / Tokelau	1		1	1	1	1
Dominikana / Dominica						1

Iz tabele 1. izuzete su države koje nemaju instalirane solarne kapacitete.

Table 1 does not include the countries without any installed solar capacities.



Slika 5. Porast korišćenja energije iz obnovljivih izvora u ukupnoj proizvodnji u svetu (Izvor: REN21, 2021)

Figure 5. The growth of renewable energy use in the total production worldwide (Source: REN21, 2021)

Izvesno je da je solarna energetika na globalnom nivou u velikoj ekspanziji u poslednjih nekoliko godina. Ovo je dobra vest i za razvijene zemlje i za zemlje u razvoju koje svoje ambicije u razvoju solarne energetike mogu ostvariti i kroz projekte poput SWERA[1] projekta i slične finansijske pomoći za usmeravanje energetskog sektora prema korišćenju OIE.

It is certain that solar energy at the global level has been greatly expanding in recent years. This is good news for both developed and developing countries, which can achieve their ambitions in solar energy development through projects such as the SWERA[1] project and similar financial assistance aimed at directing the energy sector towards the use of renewable energy sources.

1 UN su uključene u razvoj energije vetra kroz SWERA projekt (Solar Wind and Energy Resource Assessment), koji se bavi lociranjem područja pogodnih za korišćenje energije vetra i kreiranjem mapa mogućih područja za korišćenje energije vetra i sunca u 13 država u razvoju širom sveta. Tim projektom već su locirana neka pogodna područja s potencijalom od nekoliko hiljada megavata u Africi, Aziji i Južnoj Americi. Među najpodobnijim državama nalazi se afrička država Gana, u kojoj postoje lokacije za korišćenje energije vetra s potencijalom od preko 2000 MW. Takođe se preduzimaju akcije u državama poput Kenije, Nepala, Etiopije, Brazila i mnogim drugim. Ukoliko programi UN rezultiraju izgradnjom vetroelektrana, to bi bilo izuzetno važno ne samo u energetskom smislu, nego i u ekološkom smislu. Sve to zajedno trebalo bi države u razvoju da usmeri prema obnovljivim izvorima energije i time smanji pritisak na fosilna goriva.

1 The UN is involved in the development of wind energy through the SWERA project (Solar Wind and Energy Resource Assessment), which is aimed at locating areas suitable for wind energy use and creating maps of potential areas for wind and solar energy use in 13 developing countries worldwide. Through this project, some suitable areas with the potential of several thousand megawatts have already been identified in Africa, Asia, and South America. Among the most suitable countries is the African state of Ghana, where there are locations for renewable energy use with a potential of over 2000 MW. Actions are also being taken in countries such as Kenya, Nepal, Ethiopia, Brazil, and many others. If UN programs result in the construction of projects using renewable energy sources, this would be extremely important not only in terms of energy but also in environmental terms. All of this together should direct developing countries towards renewable energy sources and thus reduce the pressure on fossil fuels.

Korišćenje solarne energije s kapacitetima instaliranim do kraja 2021. godine dostiglo je kumulativni ukupni iznos od oko 942 GW. Pretnja ovako dinamičnom razvoju, međutim, može biti porast troškova fotonaponskih modula, koji su skočili za oko 57% u 2021. godini, jer su troškovi sirovina naglo porasli, što je potpuno drugačiji trend od onoga koji je prethodnih godina postojao zahvaljujući permanentnom padu troškova fotonaponskih modula. Ipak, pokazalo se da najveći apsolutni rast proizvodnje od svih obnovljivih tehnologija 2022. godine ima upravo solarna energetika, nadmašivši vetar po prvi put u istoriji. Ova stopa rasta proizvodnje odgovara nivou predviđenom od 2023. do 2030. godine u scenariju neto nulte emisije do 2050. godine. Očekuje se da će kontinuirani rast ekonomske atraktivnosti u oblasti solarne energetike, masivan razvoj u lancu snabdevanja i sve veća podrška politikama, posebno u Kini, SAD, Evropskoj uniji i Indiji, dodatno ubrzati rast kapaciteta u narednim godinama. Održavanje stope rasta proizvodnje u skladu sa scenarijom neto nulte emisije ipak iziskuje dostizanje godišnjih instalisanih kapaciteta koji su skoro tri puta veći od predviđenih za period od 2022. do 2030. godine. Za tako nešto će biti potrebna stalna ambicija politike i napori i javnih i privatnih zainteresovanih strana, posebno u oblasti integracije mreže i u rešavanju izazova politike, regulative i finansiranja u oblasti solarne energetike (Tracking Clean Energy Progress, 2023).

The use of solar energy, with installed capacities reaching a cumulative total of around 942 GW by the end of 2021, has become a major trend. However, a threat to such dynamic development may be the rising costs of photovoltaic modules, which increased by about 57% in 2021 due to sharply rising raw material costs, marking a completely different trend from the previous years of declining costs of photovoltaic modules. Nevertheless, it has been shown that solar energy had the highest absolute production growth rate of all renewable technologies in 2022, surpassing wind for the first time in history. This production growth rate corresponds to the level projected from 2023 to 2030 in the Net Zero Scenario for 2050. Continuous growth in economic attractiveness in the solar energy sector, massive development in the supply chain, and increasing policy support, especially in China, the United States, the European Union, and India, are expected to further accelerate capacity growth in the coming years. However, maintaining the production growth rate in line with the Net Zero Scenario will require achieving annual installed capacities nearly three times higher than those projected for the period from 2022 to 2030. This will require constant policy ambition and efforts from both public and private stakeholders, especially in the areas of grid integration and addressing policy, regulatory, and financing challenges in the solar energy sector (Tracking Clean Energy Progress, 2023).

2.2.2. Korišćenje energije sunca u Evropskoj uniji

Korišćenje energije iz obnovljivih izvora u zemljama članicama Evropske unije inicijalno je regulisana Direktivom br.

2.2.2. Use of Solar Energy in the European Union

The use of energy from renewable sources in European Union member states was initially regulated by Directive No.

2001/77/EC, koja je zatim izmenjena Direktivom br. 2009/28/EC Evropskog parlamenta i Saveta od 23. aprila 2009. godine, o promociji upotrebe energije iz obnovljivih izvora. Ova direktiva formulisala je nacionalne ciljeve članica Evropske unije za opšte učešće energije iz obnovljivih izvora u ukupnoj finalnoj potrošnji i učešće energije iz obnovljivih izvora u transportu. Ona je postavila pravila koja se odnose na statističke transfere između država članica, zajedničke projekte između država članica i trećih država, garancije o poreklu, administrativne procedure, informacije o prevozu i pristupu elektroenergetskim mrežama za snabdevanje energijom iz obnovljivih izvora.

Evropska komisija je 11. decembra 2018. godine donela revidiranu Direktivu br. 2018/2001/EC o korišćenju energije iz obnovljivih izvora, po kojoj bi Evropska unija do leta 2030. trebalo da dostigne cilj koji predviđa da se 32% ukupne energije u državama članicama proizvodi iz obnovljivih izvora. To je povećanje od 5% u odnosu na 27% koliko je predviđeno ranijim planovima formulisanim u prethodnoj Direktivi br. 2009/28/EC.

Posmatrajući globalnu dinamiku korišćenja obnoljivih izvora energije, može se konstatovati da se u Evropi prelazak na energiju vetra i solarnu energiju dešava brže od globalnog proseka, pri čemu su snaga vetra i solarna energija činile 22% proizvodnje električne energije u 2022. godini, u odnosu na samo 13% u 2015. godini, dok je globalni udeo korišćenja energije vetra i sunca porastao sa 4,6% na 12,1% u istom periodu.

Analizirajući podatke o korišćenju solarne energije na globalnom nivou, može se zaključiti da bi Evropska unija, da je to jedna država, imala drugi najveći solarni kapacitet na svetu sa 178.700 MW (tabela 2).

2001/77/EC, which was later amended by Directive No. 2009/28/EC of the European Parliament and of the Council of April 23, 2009, on the promotion of the use of energy from renewable sources. This Directive formulated national targets for the general participation of energy from renewable sources in the total final energy consumption of EU member states and the participation of energy from renewable sources in transport. It set rules concerning statistical transfers between member states, joint projects between member states and third countries, guarantees of origin, administrative procedures, information on transport, and access to electricity grids for energy from renewable sources.

On December 11, 2018, the European Commission adopted the revised Directive No. 2018/2001/EC on the use of energy from renewable sources, according to which the European Union should achieve the target by the summer of 2030 for 32% of the total energy in member states to be produced from renewable sources. This is an increase of 5% compared to the 27% target set out in earlier plans formulated in the previous Directive No. 2009/28/EC.

Looking at the global dynamics of renewable energy use, it can be noted that in Europe, the transition to wind energy and solar energy is happening faster than the global average, with wind power and solar energy accounting for 22% of electricity production in 2022, compared to just 13% in 2015, while globally, the share of wind and solar energy use increased from 4.6% to 12.1% over the same period.

Analysing data on the use of solar energy at the global level, it can be concluded that if the European Union were one country, it would have the second-largest solar capacity in the world, with 178,700 MW (Table 2).

Tabela 2. Instalisani solarni kapaciteti po zemljama u 2017–2021 (izvor: World Population Review)

Table 2. Installed solar capacities by country for the period 2017-2021 (Source: World Population Review)

Država / Country	Solarni kapacitet / Solar capacity 2021 (MW)	Added 2020	Total 2020	2019	2018	2017
Nemačka / Germany	58,461	4,740	53,721	48,914	45,158	42,293
Italija / Italy	22,698	1,042	21,656	20,871	20,114	19,688
Španija / Spain	15,952	3,363	12,589	11,143	7,068	7,027
Francuska / France	14,718	2,687	12,031	10,817	9,672	8,610
Holandija / Netherlands	14,249	3,299	10,950	7,226	4,608	2,911
Belgija / Belgium	6,585	1,010	5,575	4,637	4,000	3,621
Poljska / Poland	6,257	2,302	3,955	1,539	562	287
Grčka / Greece	3,530	242	3,288	2,834	2,652	2,606
Austrija / Austria	2,692	649	2,043	1,702	1,455	1,269
Madjarska / Hungary	2,131		2,131	1,400	728	344
Češka Republika/ Czech Republic	2,119	-4	2,123	2,086	2,075	2,070
Portugal / Portugal	1,801	701	1,100	901	667	579
Švedska/Sweden	1,577	470	1,107	714	428	244
Danska/Denmark	1,540	236	1,304	1,080	988	906
Rumunija / Romania	1,398	15	1,383	1,398	1,386	1,374
Bugarska / Bulgaria	1,186	89	1,097	1,048	1,033	1,036
Slovačka / Slovakia	535		535	590	472	528
Estonija / Estonia	414	206	208	121	32	15
Finska / Finland	404	86	318	222	140	82
Slovenija / Slovenia	367	-3	370	278	247	247
Litvanija / Lithuania	338	90	248	133	92	78
Kipar / Cyprus	316	87	229	151	118	110
Norveška / Norway	225	65	160	120	68	45
Luksemburg / Luxembourg	209	22	187	160	131	128
Malta / Malta	196	8	188	155	132	112
Irska / Ireland	136	43	93	58	32	17
Hrvatska/Croatia	109		109	85	68	60
Litvanija / Latvia	8	3	5	3	2	1

Globalna geopolitička situacija uticala je na kratkoročnu rastuću potražnju za ugljem u Evropi u 2022. godini i smanjenje potreba za prirodnim gasom. Bez obzira na ove okolnosti, Evropska unija je ostala na svom kursu i čak je odlučila da ubrza zelenu tranziciju kao odgovor na energetsku krizu uzrokovanu globalnim geopolitičkim dešavanjima, postavljajući nove ambiciozne ciljeve za korišćenje energije iz obnovljivih izvora do 2030. godine.

Da bi se postigao karbonski neutralan energetski sektor do 2035. godine, najjeftiniji put jeste da Evropska unija proizvodi 70–80% električne energije iz vetra i sunca, a manje od 5% iz gasa. U izveštaju objavljenom 2023. organizacija *Ember* procenila je da će 2023. godine doći do rekordnog pada korišćenja fosilnih goriva u Evropskoj uniji. Do 2030. godine samo 17% električne energije u Evropskoj uniji dolaziće iz fosilnih goriva, dok će većina regiona postupno izbaciti ugalj, prema nacionalnim planovima.

Dinamika povećanja instalisanih kapaciteta u solarnih elektranama u državama članicama Evropske unije za period 2017–2021. godina prikazana je u tabeli 2. Podaci potvrđuju trendove povećanja korišćenja solarne energije poslednjih godina gotovo u svim državama članicama. Najveći rast u instalisanim novim kapacitetima u 2020. godini ostvarile su inače vodeće evropske države u korišćenju solarne energije (Nemačka 4.740 MW, Španija 3.363 MW, Holandija 3.299 MW, Francuska 2.687 MW, Poljska 2.302 MW), dok su ostale države imale rast novih kapaciteta niži od 1.000 MW, što je proporcionalno veličini zemalja, broju stanovnika i potrebama za električnom energijom.

Posmatrajući 10 vodećih zemalja Evropske unije po pitanju novih instalisanih solarnih

The global geopolitical situation has influenced a short-term increasing demand for coal in Europe in 2022 and a reduction in the need for natural gas. Despite these circumstances, the European Union remained on its course and even decided to accelerate its green transition in response to the energy crisis caused by global geopolitical events, setting new ambitious targets for the use of renewable energy sources by 2030.

To achieve a carbon-neutral energy sector by 2035, the most cost-effective path would lead to the European Union producing 70-80% of electricity from wind and solar, and less than 5% from gas. According to a report by Ember (Ember, 2023), it is estimated that there will be a record decline in the use of fossil fuels in the European Union in 2023. By 2030, only 17% of electricity in the European Union will come from fossil fuels, while most regions will gradually phase out coal, according to national plans.

The dynamics of increasing installed capacities in solar power plants in European Union member states for the period 2017-2021 are shown in Table 2. The data confirm the trends of increasing use of solar energy in recent years in almost all member states. The largest growth in installed new capacities in 2020 was achieved by leading European countries in the use of solar energy (Germany 4,740MW, Spain 3,363MW, Netherlands 3,299MW, France 2,687MW, Poland 2,302MW), while other countries had growth below 1,000MW in new capacities, proportionally to the size of countries, population, and electricity needs.

Looking at the top 10 countries of the European Union in terms of newly installed solar power plants in 2020, there is a total of elektrana u 2020. godini, dolazi se do novih 20.263 MW. Što je oko 15% ukupnog globalnog povećanja, a trend koji se naslućuje za period 2020–2024. još je dinamičniji, mada još nije potkrepljen egzaktnim podacima publikovanim u relevantnim međunarodnim izveštajima.

Iako su rastući evropski trendovi u oblasti solarne energetike evidenti i dinamični, a u odnosu na kontinente verovatno i najkonstantniji poslednjih godina, čemu su u određenoj meri doprinele i geopolitičke okolnosti na prostoru Ukrajine, postavlja se pitanje mogućnosti Evrope da održi korak s trendovima razvoja solarne energetike koji postoje na drugim kontinentima, posebno u Aziji (npr. Kina, Indija i Turska), Australiji ili Severnoj Americi (SAD). Razlog tome je prvenstveno činjenica da Evropa ima značajna prostorna ograničenja za realizaciju velikih solarnih elektrana, što nije u tolikoj meri izraženo na navedenim kontinentima. Problem će delimično biti kompenzovan razvojem tehnologija solarnih panela, odnosno tehničkim rešenjima koja omogućavaju veću instalisanu snagu na istom prostoru (povećanje energetske efikasnosti u solarnim elektranama).

2.2.3. Korišćenje energije sunca u Republici Srbiji

Energetski deficit i neminovnost upotrebe ekološki čistih izvora energije, kao i poštovanje obaveza koje proističu iz evropskih direktiva i drugih međunarodnih obaveza u ovoj oblasti, ubrzano usmeravaju Srbiju u investicije u razvoj i eksploataciju energije sunca. Strategija razvoja energetike Republike Srbije (2015), a nakon toga i Uredba o Programu ostvarivanja Strategija

20,263MW, which is about 15% of the total global increase, and the trend anticipated for the period 2020-2024 is even more dynamic, but it is not yet supported by exact data published in relevant international reports.

Although the growing European trends in the field of solar energy are evident and dynamic, and probably the most consistent compared to continents in recent years, to some extent influenced by geopolitical circumstances in the Ukraine region, the question arises about Europe's ability to keep up with the trends in the development of solar energy existing on other continents, especially in Asia (e.g., China, India, and Turkey), Australia, or in North America (USA). The reason for this is primarily the significant spatial limitations in Europe for the realization of large solar power plants, which are not expressed to the same extent on the aforementioned continents. The problem will be partially compensated by the development of solar panel technologies, i.e., technical solutions that enable higher installed power in the same space (increased energy efficiency in solar power plants).

2.2.3. Solar Energy Utilization in the Republic of Serbia

The energy deficit and the inevitability of using environmentally clean energy sources, as well as compliance with obligations arising from European directives and other international obligations in this area, are rapidly directing Serbia towards investments in the development and exploitation of solar energy. The Energy Development Strategy of the Republic of Serbia (2015), and subsequently the Regulation on the razvoja energetike Republike Srbije (2017), daju dovoljno prostora solarnoj energetici i stvaraju preduslove za ubrzani razvoj ovog energetskog sektora. O tome govori vrlo intenzivan razvoj projekata u oblasti korišćenja solarne energije u 2023. godini, ali i porast realizovanih projekata za period 2017–2021. (tabela 3).

Program for Implementing the Energy Development Strategy of the Republic of Serbia (2017), provide sufficient space for solar energy and create conditions for the accelerated development of this energy sector. This is evidenced by the very intensive development of projects in the field of solar energy utilization in 2023, as well as the increase in realized projects for the period 2017-2021 (Table 3).

Tabela 3. Instalisani solarni kapaciteti u Republici Srbiji za period 2017–2021 (Izvor: World Population Review, 2022)

Table 3. Installed solar capacities in the Republic of Serbia for the period 2017-2021 (Source: World Population Review, 2022)

Country	Solar capacity 2021 (MW)	Added 2020	Total 2020	2019	2018	2017
Serbia	52	21	31	23	21	18

U poređenju s drugim zemljama Zapadnog Balkana koje još nemaju status članice Evropske unije, jedino se Severna Makedonija nalazi ispred Republike Srbije po instalisanoj snazi solarnih elektrana, sa ukupnim kapacitetom od 94 MW zaključno sa 2021. godinom.

In comparison with other countries in the Western Balkans that are not yet EU members, only North Macedonia is ahead of the Republic of Serbia in terms of installed solar power capacity, with a total capacity of 94 MW as of 2021.

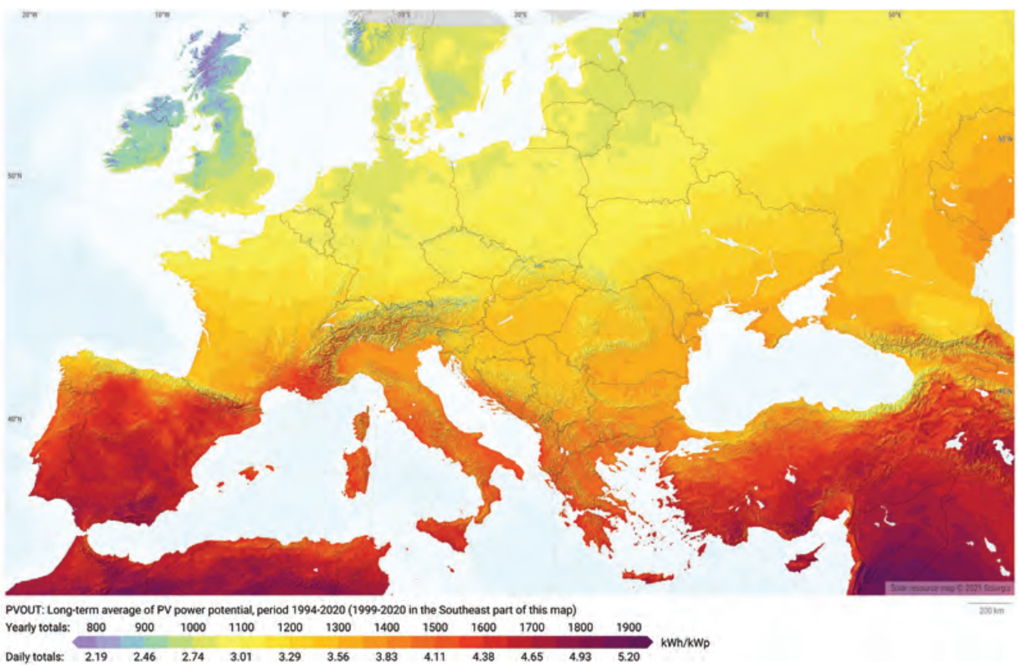
2.2.3.1. Potencijali i pogodne lokacije za korišćenje solarne energije u Srbiji

Na većem delu teritorije Srbije broj časova sunčevog zračenja znatno je veći nego u mnogim evropskim zemljama (između 1.500 i 2.200 časova godišnje). Prosečan intenzitet sunčevog zračenja na teritoriji Srbije kreće se od 1,1 kWh/m^2 dnevno na severu do 1,7 kWh/m^2 dnevno na jugu tokom januara, a od 5,9 do 6,6 kWh/m^2 dnevno tokom jula. Na godišnjem nivou, prosečna vrednost energije zračenja kreće se od 1.200 kWh/m^2 godišnje u severozapadnoj Srbiji do 1.550 kWh/

2.2.3.1. Potentials and Suitable Locations for Solar Energy Utilization in Serbia

Across most of the territory of Serbia, the number of hours of sunlight is significantly higher than in many European countries (between 1,500 and 2,200 hours annually). The average intensity of solar radiation in Serbia ranges from 1.1 kWh/m2/day in the north to 1.7 kWh/m2/day in the south during January, and from 5.9 to 6.6 kWh/m2/day during July. On an annual basis, the average radiation energy value ranges from 1,200 kWh/m2/year in northwestern Serbia to 1,550 kWh/m2/year in southeastern m² godišnje u jugoistočnoj Srbiji, dok u centralnom delu iznosi oko 1.400 kWh/m² godišnje. Tehnički iskoristiv energetski potencijal za konverziju energije Sunca u toplotnu energiju (za pripremu tople vode i druge namene) procenjen je na 0,194 Mtoe godišnje, uz pretpostavku primene solarnih termalnih kolektora na 50% objekata u zemlji. Na osnovu trenutno raspoloživih kapaciteta elektroenergetskog sistema Srbije za obezbeđenje tercijalne rezerve usvojeno je da je maksimalni tehnički iskoristiv kapacitet solarnih elektrana 450 MW, odnosno njihov tehnički iskoristiv potencijal iznosi 540 GWh godišnje (0,046 Mtoe/godišnje) (Strategija razvoja energetike Republike Srbije, 2015). Srbija se svrstava u područja sa znatnim energetskim potencijalom u domenu korišćenja solarne energije (slika 6), ali i energije vetra i drugih obnovljivih energetskih izvora.

Serbia, while in the central part, it is around 1,400 kWh/m2/year. The technically usable energy potential for converting solar energy into thermal energy (for hot water preparation and other purposes) is estimated at 0.194 Mtoe annually, assuming the application of solar thermal collectors on 50% of the buildings in the country. Based on the currently available capacities of the Serbian power system to provide tertiary reserve, it is adopted that the maximum technically utilizable capacity of solar power plants is 450 MW, with their technically utilizable potential amounting to 540 GWh/year (0.046 Mtoe/year) (Energy Development Strategy of the Republic of Serbia, 2015). Serbia ranks among areas with significant energy potential in the domain of solar energy utilization (Figure 6), as well as wind energy and other renewable energy sources.



Slika 6. Mapa fotonaponskog električnog potencijala Evrope (kWh/kWp) (izvor: SOLARGIS, 2021)

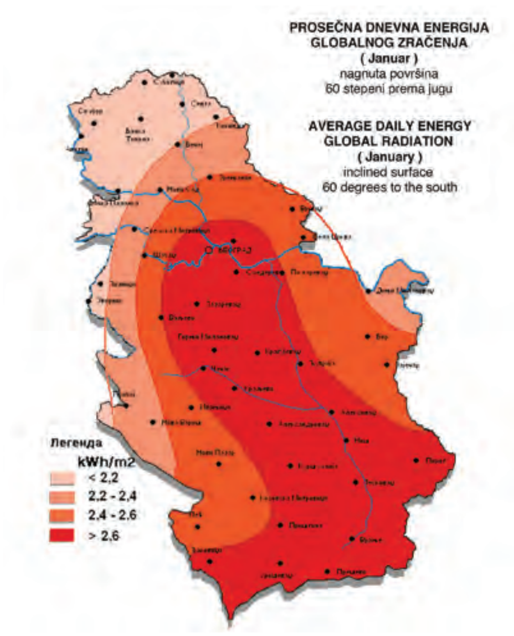
Figure 6. Map of photovoltaic electric potential of Europe (kWh/kWp) (Source: SOLARGIS, 2021)

Ova relativno povoljna ocena energetskog potencijala, posebno u vetru i sunčevoj energiji, poslužila je za detaljnija istraživanja potencijala za izgradnju vetroelektrana i solarnih elektrana na teritoriji Republike Srbije, koja su dobila svoju formu kroz izradu Studije energetskog potencijala Srbije (SEPS) za korišćenje sunčevog zračenja i energije vetra (NPEE, Evidencioni broj EE704-1052A) čiji je naručilac bilo Ministarstvo nauke i zaštite životne sredine, a obrađivač Centar za multidisciplinarne studije Univerziteta u Beogradu u novembru 2004.

U kontekstu potencijala za korišćenje solarne energije, urađene su mape koje su prikazane u nastavku (slike 7–13).

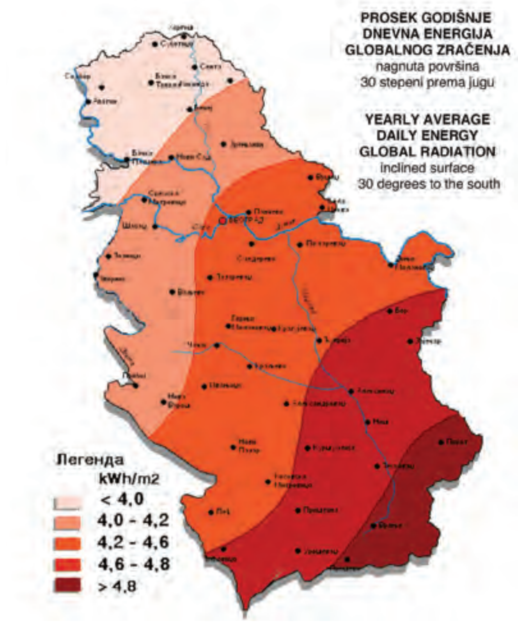
This relatively favourable assessment of energy potential, especially in wind and solar energy, has led to more detailed research into the potential for building wind farms and solar power plants in the territory of the Republic of Serbia, which took shape through the preparation of the Energy Potential Study of Serbia (EPSS) for the use of solar radiation and wind energy (NPEE, Registration Number EE704-1052A) commissioned by the Ministry of Science and Environmental Protection, and processed by the Centre for Multidisciplinary Studies of the University of Belgrade in November 2004.

In the context of the potential for solar energy utilization, maps have been created, which are presented below (Figures 7–13).



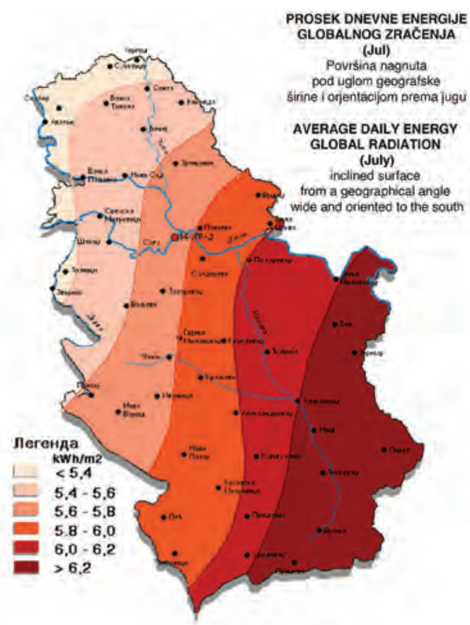
Slika 7. Prosečna godišnja dnevna energija globalnog zračenja u Srbiji na površinu sa nagibom 60° i orijentacijom prema jugu (kWh/m^2) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 7. Average annual daily global radiation energy in Serbia on a surface with a 60° slope and orientation towards the south (kWh/m2) (Source: Energy Potential Study of Serbia, 2004)



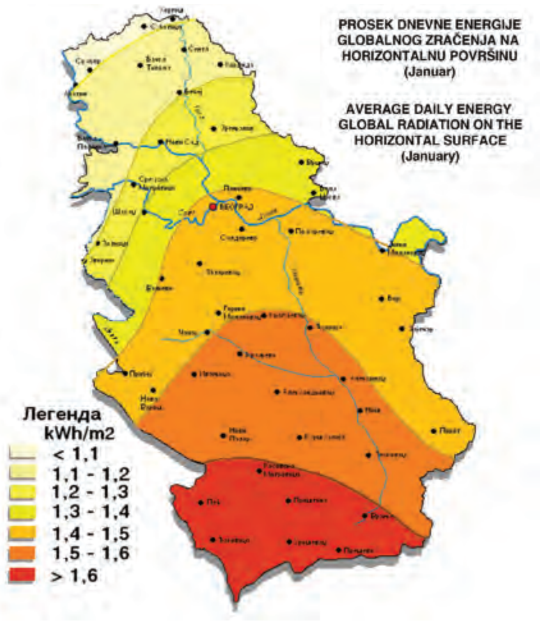
Slika 8. Prosečna godišnja dnevna energija globalnog zračenja u Srbiji na površinu sa nagibom 30° i orijentacijom prema jugu (kWh/m^2) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 8. Average annual daily global radiation energy in Serbia on a surface with a 30° slope and orientation towards the south (kWh/m2) (Source: Energy Potential Study of Serbia, 2004



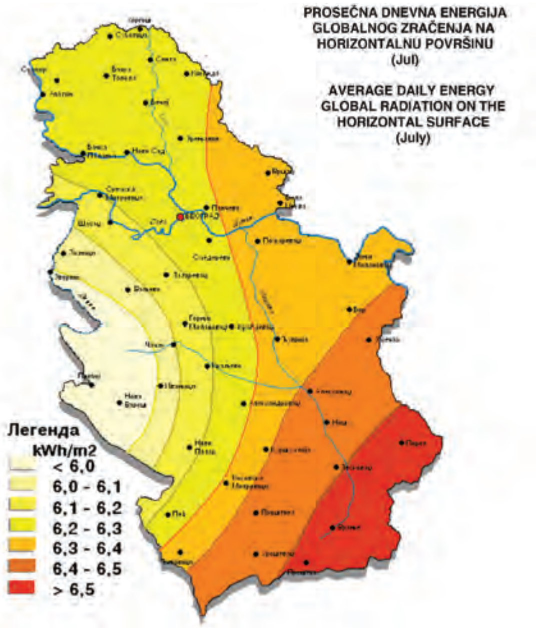
Slika 9. Prosečna dnevna energija globalnog zračenja na površinu sa nagibom jednakim geografskoj širini i orijentacijom prema jugu u julu (kWh/m2) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 9. Average daily global radiation energy on a surface with a slope equal to the geographical latitude and orientation towards the south in July (kWh/m2)



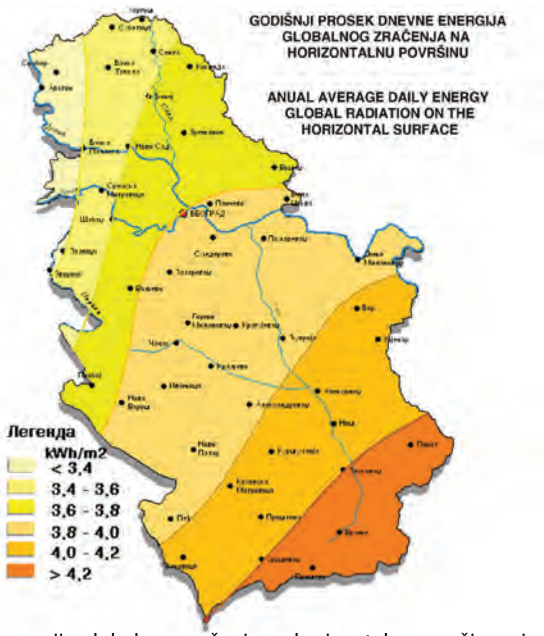
Slika 10. Prosečna dnevna energija globalnog zračenja na horizontalnu površinu u januaru (kWh/m²) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 10. Average daily global radiation energy on a horizontal surface in January (kWh/m2) (Source: Energy Potential Study of Serbia, 2004)



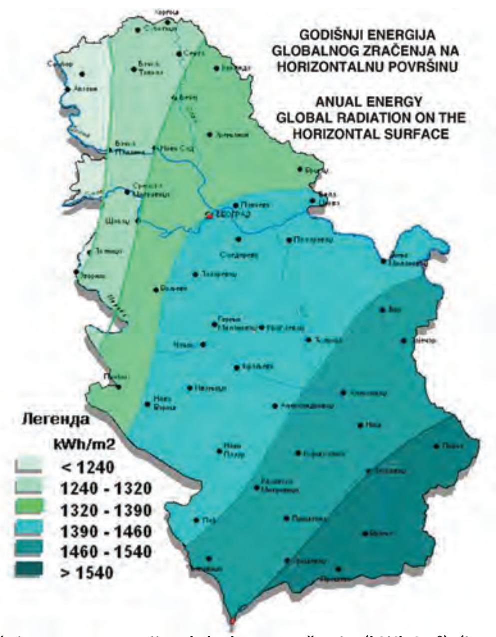
Slika 11. Prosečna dnevna energija globalnog zračenja na horizontalnu površinu u julu (kWh/m²) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 11. Average daily global radiation energy on a horizontal surface in July (kWh/m2 (Source: Energy Potential Study of Serbia, 2004)



Slika 12. Prosečna dnevna energija globalnog zračenja na horizontalnu površinu u januaru (kWh/m^2) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 12. Average daily global radiation energy on a horizontal surface in January (kWh/m2)(Source: Energy Potential Study of Serbia, 2004)



Slika 13. Vrednosti godišnje sume energije globalnog zračenja (kWh/m^2) (izvor: Studija energetskog potencijala Srbije, 2004.)

Figure 13. Values of the annual sum of global radiation energy (kWh/m2) (Source: Energy Potential Study of Serbia, 2004)

Rezultati ove Studije, dobijeni egzaktnom analizom raspoloživih podataka merenja i izvršenih procena, pokazuju da Srbija raspolaže natprosečnim resursima energije vetra i sunčevog zračenja u odnosu na zemlje kontinentalne Evrope.

Metodika izrade karata (slike 7–13) zasniva se na uzoru Solarnih atlasa Evrope (CEC 1984a, b i CEC, 2000a). Uticaj topografije je u ovom slučaju uključen samo indirektno, u onoj meri u kojoj utiče na podatke merenja, jer mape odražavaju samo podatke izmerene na meteorološkim stanicama, koje se pretežno nalaze na malim nadmorskim visinama. Sve vrednosti su date u kWh/m^2.

Detaljna objašnjenja svake pojedinačne mape data su u Studiji energetskog potencijala Srbije (2004), a osnovni zaključci ukazuju na to da u januaru energija relativno ravnomerno opada od severa ka jugu. To je posledica činjenice da je u zimskim mesecima količina oblačnosti dosta ravnomerno raspoređena po čitavoj teritoriji, pa tako u prvi plan dolazi uticaj geografske širine. U julu je energija najmanja u zapadnom delu zemlje. U letnjim mesecima dnevna oblačnost je najizraženija u planinama Dinarskog sistema, što umanjuje uticaj geografske širine, odnosno visine sunca. Godišnja mapa deluje kao kompromis prve dve.

Što se tiče energije zračenja, na površinama s nagibom i orijentaciji ka jugu postoje veći potencijali za korišćenje energije sunca, a sunčeva energija prilično ravnomerno raste od severozapada ka jugoistoku.

Imajući u vidu da je Studija energetskog potencijala Srbije rađena pre 20 godina i da su evidentne promene klime i na makro i na mikro nivou, pogotovo one koje se odnose

The results of this study, obtained through precise analysis of available measurement data and assessments, show that Serbia possesses above-average wind and solar radiation energy resources compared to countries in continental Europe.

The methodology for creating maps (Figures 7–13) was inspired by the Solar Atlases of Europe (CEC 1984a, b and CEC, 2000a). The impact of topography in this case is included only indirectly to the extent that it affects the measurement data because the maps reflect only the data measured at meteorological stations, which are mostly located at low altitudes. All values are given in kWh/m2.

Detailed explanations of each individual map are provided in the Energy Potential Study of Serbia (2004), and the basic conclusions indicate that in January, energy relatively uniformly decreases from north to south. This is due to the fact that in winter months, the amount of cloud cover is quite evenly distributed throughout the territory, thus highlighting the influence of geographical latitude. In July, energy is lowest in the western part of the country. In summer months, daily cloudiness is most pronounced in the mountains of the Dinaric system, which reduces the influence of geographical latitude, i.e., the height of the sun. The annual map acts as a compromise of the first two.

Regarding radiation energy, there are higher potentials for solar energy utilization on surfaces with slopes and orientations facing south, and solar energy steadily increases from northwest to southeast.

Given that the Energy Potential Study of Serbia was conducted 20 years ago and that there are evident climate changes at both macro and micro levels, especially na povećanje temperature koje je donekle povezano i sa insolacijom, izvesno je da su potencijali za razvoj solarne energetike još povoljniji nego što je to bio slučaj u vremenu kad je vršena procena potencijala za korišćenje solarne energije na kojoj se zasniva Studija iz 2004. godine. I pored toga, poseban doprinos ove Studije jeste u tome što je poslužila kao osnov za privlačenje velikog broja investitora koji razmišljaju o ulaganjima u solarnu energetiku u Republici Srbijina i započinjanju razvoja projekata solarnih elektrana.

2.2.3.2. Problemi u realizaciji projekata solarnih elektrana u Srbiji

Problemi u realizaciji projekata solarnih elektrana u Srbiji, posebno velikih (preko 100 MW) mnogobrojni su, a autor se na osnovu iskustva u realizaciji velikog broja takvih projekata na teritoriji Republike Srbije i u regionu, opredelio za opisan prikaz, uz fokus na probleme koji su ključni. Namera autora nije da kritikuje, već da afirmativno iznese svoje viđenje problema i ukaže na one probleme koji usporavaju dinamiku razvoja solarne energetike u Srbiji. Takođe, imajući u vidu period od pisanja do štampanja ove knjige, postoji mogućnost da su neki od problema već u procesu rešavanja (prevazilaženja) ili su možda otklonjeni.

Kao prividno jednostavni projekti za realizaciju, solarne elektrane ipak imaju kompleksnu proceduru izdavanja potrebne dokumentacije za izgradnju i potrebnih dozvola.

Prema izveštaju Svetske banke (World Bank, 2020), Srbija se na listi *Duing biznis* (Doing Business, 2020) nalazi na 44. poziciji, što je

those related to temperature increases somewhat associated with insolation, it is certain that the potentials for solar energy development are even more favourable than they were at the time of estimating the potentials for solar energy utilization on which the 2004 study was based. Nevertheless, the special contribution of this study is that it served as a basis for attracting a large number of investors to consider investments in solar energy in the Republic of Serbia and initiate the development of solar power plant projects.

2.2.3.2. Problems in the Implementation of Solar Power Plant Projects in Serbia

The problems in the implementation of solar power plant projects in Serbia, especially large ones (over 100MW), are numerous, and based on the experience in implementing a large number of such projects in the territory of the Republic of Serbia and the region, the author has opted to describe them descriptively, focusing on key problems. The author's intention is not to criticize but to affirmatively present his view of the problems and point out those that slow down the dynamics of solar energy development in Serbia. Also, considering the period from writing to printing this book, there is a possibility that some of the problems are already in the process of being resolved or have perhaps been addressed.

Projects for solar power plants, seemingly simple to implement, still have a complex procedure leading to the issuance of the necessary documentation for construction and permits.

According to the World Bank report (World Bank, 2020), Serbia ranks 44th on the za 4 pozicije bolje u odnosu na prethodnu listu iz 2019. godine. Prema tom izveštaju Srbija je zakomplikovala pokretanje biznisa time što zahteva od preduzetnika da pribave elektronski sertifikat i posebno registruju krajnje stvarne vlasnike nakon osnivanja. S druge strane, Srbija je olakšala postupanje s građevinskim dozvolama implementacijom onlajn portala i smanjenjem administrativne takse. To je uticalo da se DTF (*distance to frontier*) Srbije popeo na 75,7 poena, za razliku od 73,49 poena u 2018, 73,13 poena u 2017, odnosno 72,87 poena samo godinu dana ranije.

Ishodovanje potrebne dokumentacije, uslova nadležnih institucija i dozvola, međutim, i dalje je okarakterisano izrazito dugim trajanjem i nepredvidivom i komplikovanom procedurom koja podrazumeva veliki broj koraka, čiji je ishod neizvestan. Samim tim, sve investitore koji su započeli projekte ili one koji ih tek planiraju čeka dug i mukotrpan posao bez ikakve sigurnosti po pitanju odobrenja gradnje. Iako je ovaj problem odavno prepoznat od strane svih učesnika u procesu, političkih struktura, administracije i investitora, do sada se nije dovoljno uradilo na njegovom prevazilaženju (Josimović, 2017).

Slede najznačajniji problemi u realizaciji projekata solarnih elektrana u Srbiji, koji su podeljeni u nekoliko grupa:

1. Mogućnost priključenja na elektromrežu Srbije (EMS) – To predstavlja osnovni preduslov za započinjanje razvoja projekta solarne elektrane i drugih energetskih objekata. Iako deluje jednostavno, treba imati u vidu da elektromreža Srbije nema neograničene mogućnosti da prihvati energiju iz novih elektrana, posebno

Doing Business list (Doing Business, 2020), which is 4 positions better compared to the previous year 2019. According to this report, Serbia has complicated starting a business by requiring entrepreneurs to obtain an electronic certificate and register ultimate beneficial owners separately after establishment. On the other hand, Serbia has facilitated dealing with construction permits by implementing an online portal and reducing administrative fees. This has resulted in Serbia's DTF (the distance to frontier) rising to 75.7 points, compared to 73.49 points in 2018, 73.13 points in 2017, and 72.87 points just a year earlier.

However, the procedure for obtaining the necessary documentation, conditions of competent institutions and permits still involves an extremely long duration, unpredictable and complicated procedures that entail a large number of steps and whose outcome is uncertain. Consequently, all investors who have started projects or those who are planning to do so face a long and laborious process with no security that construction will be approved. Although this problem has long been recognized by all participants in the process, political structures, administration, and investors, not enough has been done so far to overcome this problem (Josimović, 2017).

The following are the most significant problems in the implementation of solar power plant projects in Serbia, which are divided into several groups:

1. Possibility of Connecting to the Serbian Electrical Grid (EMS) – This represents a fundamental prerequisite for starting the development of a solar power plant project and other energy facilities. Although it may seem simple, it is important to consider that the Serbian electrical grid does not have unlimited capacity to accept energy imajući u vidu ogromno interesovanje investitora u oblasti razvoja projekata koji koriste obnovljive izvore energije. Problem nije samo u prihvatanju novih instalisanih kapaciteta u elektromrežu, već i u mogućnostima efikasnog upravljanja sistemom koji prihvata varijabilnu (ne konstantnu) energiju iz obnovljivih izvora.

2. Planska/urbanistička dokumentacija – Praksa u realizaciji projekata solarnih elektrana u Srbiji, u kontekstu stvaranja planskog osnova za njihovu dalju realizaciju, vodi kroz posebnu izradu planova detaljne regulacije ili urbanističkih projekata. Ne postoje primeri direktnog sprovođenja za ovakve projekte iz planova višeg reda (prostornih planova jedinica lokalne samouprave ili regionalnih prostornih planova), dok je direktno sprovođenje iz prostornih planova područja posebne namene moguće, ali je zbog nadležnosti za pokretanje procedure, sprovođenje i usvajanje ovakvih planova veoma komplikovano za investitore. Naime, u mnogim lokalnim samoupravama u Srbiji postojeći prostorni planovi neadekvatnog su sadržaja u pogledu izgradnje solarnih elektrana. Taj aspekt je obično obrađen samo u kontekstu identifikacije potencijala za korišćenje obnovljivih izvora energije, često samo u tekstualnom delu planskog dokumenta, zbog čega nije moguće direktno sprovođenje za ovakve projekte. Izrada planova detaljne regulacije ili urbanističkih projekata, dakle, opcije su kojima se započinje razvoj projekata solarnih elektrana u Srbiji. Koji od ova dva urbanistička dokumenta je opcija za investitora zavisi od prostornih planova višeg reda, u kojima je propisana urbanistička razrada za ovakvu vrstu

from new power plants, especially given the immense interest from investors in developing projects that use renewable energy sources. The issue is not only about integrating new installed capacities into the electrical grid, but also about the capabilities for efficiently managing a system that accepts variable (non-constant) energy from renewable sources.

2. Planning/Urbanistic Documentation - The practice of implementing solar power plant projects in Serbia, in terms of creating a planning basis for their further implementation, involves the special development of detailed regulation plans or urbanistic projects. There are no examples of direct implementation for such projects from higher-order plans (spatial plans of local government units or regional spatial plans), while direct implementation from spatial plans of areas of special purpose is possible but highly complex for investors due to the responsibilities involved in initiating, implementing, and adopting such plans. In many local governments in Serbia, existing spatial plans are inadequate in terms of constructing solar power plants. This aspect is usually only addressed in the context of identifying potential for renewable energy use, often only in the textual part of the planning document, making direct implementation for such projects impossible. Therefore, the options for starting the development of solar power plant projects in Serbia are through the creation of detailed regulation plans or urbanistic projects. Which of these two documents is an option depends on the higher-order spatial plans where urban development for such a project is prescribed. In the case of detailed regulation plans, the procedure is more complex and lengthy, while the creation projekata. U slučaju izrade planova detaljne regulacije, procedura je komplikovanija i traje dugo, dok je izrada urbanističkih projekata povoljnija u smislu trajanja procedura, ali manje transparentna u odnosu na plan detaljne regulacije. U svakom slučaju, potreba da se za solarne elektrane radi poseban urbanistički dokument predstavlja za investitore dodatno vreme, dodatni novac i dodatnu neizvesnost za realizaciju projekta.

3. Tehnička (projektna) dokumentacija – Procedura izrade tehničke dokumentacije uslovljena je usvajanjem planske/urbanističke dokumentacije i ishodovanjem Lokacijskih uslova i pre toga ne može formalno započeti. Ova faza u realizaciji projekata podrazumeva čitav niz proceduralnih i formalnih postupaka i izradu dokumenata koji takođe traju određen vremenski period. Kao karakterističan primer duge procedure može se navesti procedura za Studiju o proceni uticaja projekta na životnu sredinu, koja je reprezentativan primer i u odnosu na temu ove knjige. Ova studija je sastavni deo tehničke dokumentacije i radi se u skladu sa propozicijama: Zakona o zaštiti životne sredine („Službeni glasnik RS", 135/04, 36/09 72/09 – 43/11 – Ustavni sud i 14/2016), Zakona o proceni uticaja na životnu sredinu („Službeni glasnik RS", br. 135/04 i 36/09) i Uredbe o utvrđivanju Liste projekata za koje je obavezna procena uticaja i Liste projekata za koje se može zahtevati procena uticaja na životnu sredinu („Službeni glasnik RS", br. 114/08). Interesantno je da Uredba o utvrđivanju Liste projekata za koje je obavezna procena uticaja i Liste projekata za koje se može zahtevati procena uticaja na životnu

of urbanistic projects is more favourable in terms of duration but less transparent compared to the detailed regulation plan. In any case, the need to produce a specific urbanistic document for solar power plants represents additional time, additional money, and additional uncertainty for investors in project realization..

3. Technical (Project) Documentation – The procedure for creating technical documentation is contingent on the approval of planning/urbanistic documentation and the procurement of Location Conditions and cannot formally commence beforehand. This phase in project realization encompasses a series of procedural and formal steps and the creation of documents, which also take a considerable amount of time. A characteristic example of a lengthy procedure can be cited as the procedure for the Environmental Impact Assessment Study, which is also a representative example concerning the theme of this book. This study is an integral part of the technical documentation and is conducted in accordance with the provisions of the Law on Environmental Protection ("Official Gazette of RS", No. 135/04, 36/09, 72/09 – 43/11 Constitutional Court and 14/2016); the Law on Environmental Impact Assessment ("Official Gazette of RS", Nos. 135/04 and 36/09); and the Regulation on determining the List of Projects for which an Impact Assessment is mandatory and the List of Projects for which an Impact Assessment may be requested ("Official Gazette of RS", No. 114/08). Interestingly, the regulation on determining the List of Projects for which an Impact Assessment is mandatory and the List of Projects for which an Impact Assessment may be requested does not recognize solar power plants as sredinu ne prepoznaje solarne elektrane kao projekte za koje se radi Studija o proceni uticaja projekta na životnu sredinu, bez obzira na instalisanu snagu, pa čak i u slučajevima kad instalisana snega prelazi nekoliko desetina ili stotina megavata. To deluje neprihvatljivo ako se ima u vidu da je za 1 MW u solarnoj elektrani potrebno i do 2 ha zemljišta (u zavisnosti od tipa solarnih panela) i nagoveštava promenu Pravilnika u ovom delu. Za druge projekte, poput trafostanica odnodno dalekovoda, koji predstavljaju deo integralnog projekta solarne elektrane, potrebna je, međutim, izrada Studije o proceni uticaja, koja predstavlja sastavni deo dokumentacije za pribavljanje građevinske dozvole (Zakon o planiranju i izgradnji, „Službeni glasnik RS", br. 72/2009, 81/2009 – ispr., 64/2010 – odluka US, 24/2011, 121/2012, 42/2013 – odluka US, 50/2013 – odluka US, 98/2013 – odluka US, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 – dr. zakon, 9/2020, 52/2021 i 62/2023). Podrazumeva veoma dugotrajnu zakonsku proceduru koja se odvija u tri faze, uz transparentnu participaciju zainteresovanih institucija, javnosti i nevladinog sektora. Sprovođenje navedenih proceduralnih faza može trajati čak i godinu dana (Zakon o proceni uticaja na životnu sredinu). Ova činjenica utiče na spremnost investitora da ulažu u solarnu energetiku jer povećava neizvesnost u realizaciji projekta. Pored toga, poseban problem u realizaciji projekata solarnih elektrana može se smatrati nedovoljno efikasna i konceptualno neodgovarajuće osmišljena procedura izrade i usvajanja Planova upravljanja građevinskim otpadom, koji se rade za potrebe dobijanja građevinske dozvole prema Uredbi o

projects for which an Environmental Impact Assessment Study is conducted, regardless of installed power, even in cases where installed capacity exceeds several tens or hundreds of MW. This seems unacceptable considering that up to 2 hectares of land may be required for 1 MW in a solar power plant (depending on the type of solar panels) and suggests a need for a change in the regulations in this part. However, for other projects, such as substations and/or transmission lines, which are part of an integral solar power plant project, the creation of an Environmental Impact Assessment Study is necessary and forms part of the documentation for obtaining a construction permit (Law on Planning and Construction, "Official Gazette of RS", Nos. 72/2009, 81/2009 - correction, 64/2010 - Constitutional Court decision, 24/2011, 121/2012, 42/2013 - Constitutional Court decision, 50/2013 - Constitutional Court decision, 98/2013 - Constitutional Court decision, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - other laws, 9/2020, 52/2021, and 62/2023). This involves a very lengthy legal procedure, carried out in three phases, with transparent participation from interested institutions, the public, and the NGO sector. The implementation of these procedural phases can take even a year (Law on Environmental Impact Assessment). This fact affects investors' willingness to invest in solar energy as it increases uncertainty in project realization. Additionally, a particular issue in implementing solar power plant projects can be considered the insufficiently effective and inadequately conceptualized procedure for creating and adopting Waste Management Plans required for obtaining a construction permit according to the Regulation on the manner and procedure of waste management from construction and načinu i postupku upravljanja otpadom od građenja i rušenja („Sl. glasnik RS", br. 93/2023 i 94/2023 – ispr). Naime, često se kompleksi solarnih elektrana sastoje od pojedinačnih projekata (objekata) koji imaju različite nadležnosti prilikom ishodovanja građevinske dozvole. Na primer, za dobijanje građevinske dozvole, solarna elektrana (solarni paneli) ili trafostanica u nadležnosti su Ministarstva/Pokrajine, dok su pristupni putevi, na primer, u nadležnosti lokalne samouprave za dobijanje građevinske dozvole, iako svi ovi pojedinačni projekti predstavljaju jedinstvenu celinu koju nazivamo solarna elektrana. Prema trenutnoj praksi u Srbiji, za svaki pojedinačni projekat u okviru jedinstvenog kompleksa (solarna elektrana ili vetroelektrana, itd.) potrebno je uraditi zaseban Plan upravljanja građevinskim otpadom, umesto da se čitav kompleks sagleda kroz jedinstven Plan upravljanja otpadom, koji se zatim prilaže odgovarajućim instancama na odlučivanje i usvajanje. To je metodološki i konceptualno jedini logičan i konzistentan pristup, a svaki drugačiji pristup predstvlja dodatne finansijske i proceduralne poteškoće za investitore.

4. Izdavanje uslova relevantnih institucija – Prilikom izrade planske dokumentacije i ishodovanja Lokacijskih uslova koje sledi nakon toga, što sve prethodi izradi tehničke dokumentacije, sprovode se postupci pribavljanja uslova relevantnih institucija – imalaca javnih ovlašćenja. Problem je u vezi s potrebnim vremenom za izdavanje uslova, s jedne strane, i potencijalno zahtevnim uslovima koje imaoci javnih ovlašćenja mogu formulisati kroz svoje uslove, s druge strane. Sama procedura u kojoj tehničko

demolition ("Official Gazette of RS", Nos. 93/2023 and 94/2023 - correction). Often, solar power plant complexes consist of individual projects (facilities) with different responsibilities during the construction permit process. For example, a solar power plant (solar panels) or substation may be under the jurisdiction of the Ministry/Province for obtaining a construction permit, while access roads may be under the jurisdiction of the local government for obtaining a construction permit, even though all these individual projects represent a unified whole called a solar power plant. According to current practice in Serbia, it is necessary for each individual project within a single complex (solar power plant or wind farm, etc.) to have a separate Waste Management Plan, instead of viewing the entire complex through a unified Waste Management Plan which is then submitted to the relevant instances for decision-making and adoption. This is the only methodologically and conceptually logical and consistent approach, and any other approach represents additional financial and procedural difficulties for investors.

4. Issuing Conditions from Relevant Institutions – During the creation of planning documentation and the issuance of Location Conditions that follows, which all precede the creation of technical documentation, procedures are carried out to obtain conditions from relevant institutions—holders of public authority. The issue involves the time required to issue these conditions, on one hand, and potentially demanding conditions that holders of public authority might set forth, on the other hand. The procedure in which a technical person drafts the conditions that subsequently need to be signed by lice koncipira uslove koje je posle toga neophodno da potpiše odgovorno lice u instituciji koja je imalac javnih ovlašćenja, a koje često zbog prirode posla nije uvek dostupno, može dovesti do zastoja i produžavanja procesa dobijanja uslova. Pri tome, treba imati u vidu da postoje dva „kruga" ishodovanja uslova: 1) za potrebe izrade planske/urbanističke dokumentacije i 2) za potrebe Lokacijskih uslova, odnosno izradu tehničke dokumentacije. Nakon toga sledi i faza davanja mišljenja na plansku dokumentaciju u cilju provere primene izdatih uslova, što iziskuje dodatno vreme. Što se tiče eventualnih zahtevnih uslova imalaca javnih ovlašćenja, oni se uglavnom odnose na potrebu vršenja ciljanih opservacija, koje mogu biti zahtevne i vremenski (čak i do godinu dana) i finansijski. Kao primer mogu se navesti opservacije biodiverziteta (nadležni zavodi za zaštitu prirode) ili izrada Studije zaštite nepokretnih kulturnih dobara (nadležni zavodi za zaštitu spomenika kulture). Iako su apekti zaštite biodiverziteta i nepokretnih kulturnih dobara od posebnog značaja i za zaštitu životne sredine i za finansiranje projekata od strane međunarodnih finansijskih institucija, ovakvi zahtevi su ipak posledica nedovoljno razvijenog informacionog sistema o prostoru i dodatno opterećuju razvoj projekata solarnih elektrana. Izazov može biti i izlaženje iz nadležnosti za određenu oblast, što može stvoriti koliziju u odnosu na uslove drugih institucija. Takođe, državne agencije i javna preduzeća neretko prekoračuju rokove propisane zakonom, a da pritom investitori i kompanije nemaju mogućnosti da utiču na zaposlene u javnim preduzećima da se procedura ubrza. Uzrok

the responsible person in the institution holding public authority, who often due to the nature of their work is not always available, can lead to delays and prolong the process of obtaining conditions. It should be noted that there are two "rounds" of obtaining conditions: 1. For the purposes of creating planning/urbanistic documentation; and 2. For the purposes of Location Conditions, or the creation of technical documentation. Following this, there is also a phase of providing opinions on the planning documentation to verify the application of issued conditions, which requires additional time. As for the potentially demanding conditions of holders of public authority, they generally relate to the need to conduct targeted observations which can be demanding both in terms of time (even up to a year) and financially. Examples include biodiversity observations (competent institutes for nature conservation) or the creation of a Study for the protection of immovable cultural assets (competent institutes for the protection of cultural monuments). Although aspects of biodiversity and immovable cultural asset protection are of particular importance both for environmental protection and for the financing of projects by international financial institutions, these demands are still a consequence of an underdeveloped spatial information system and further burden the development of solar power plant projects. The challenge can also include stepping out of jurisdiction for a certain area, which can create a collision in relation to the conditions of other institutions. Additionally, state agencies and public companies often exceed legally prescribed deadlines, while investors and companies have no way to influence employees in public companies to expedite the process. The cause is sometimes je ponekad i objektivne prirode, a odnosi se na neproporcionalan broj kadrova koji rade na izdavanju uslova u odnosu na veliki broj predmeta koje treba obraditi.

5. Rešavanje imovinsko-pravnih odnosa – Investitori često imaju teškoće kod utvrđivanja vlasništva nad uglavnom velikim brojem malih parcela i, kao posledica toga, u rešavanju imovinsko-pravnih odnosa nad zemljištem koje je uslov za realizaciju projekata većih solarnih elektrana. Uzroci su mnogobrojni, od dugogodišnjeg nesprovođenja promena vlasništva od strane fizičkih lica u procesu nasleđivanja ili kupoprodaje, ali i pogrešno upisanih podataka u katastru nepokretnosti.

Pored navedenih osnovnih problema u realizaciji solarnih elektrana Srbiji, postoje problemi koji se odnose i na korišćenje poljoprivrednog zemljišta u nepoljoprivredne svrhe, plaćanje velikog broja taksi u toku realizacije projekta, finansiranje projekata, mogućnost dobijanja statusa povlašćenog proizvođača i slično, što ipak zadire u oblast ekonomije i agro-ekonomije i iziskivalo bi posebnu analizu kojom bi se izašlo iz okvira teme ove knjige.

S obzirom na to da je ekspanzija u razvoju velikih solarnih elektrana u Srbiji započela relativno skoro (od 2021. godine), ne čudi da se navedeni ključni problemi postepeno prepoznaju od strane svih aktera u procesu realizacije projekata solarnih elektrana, što je svakako ohrabrujuće za institucije, investitore, eksperte i za stvaranje boljeg ambijenta za investicije u oblasti solarne energetike u Srbiji.

of an objective nature and relates to the disproportionate number of staff involved in issuing conditions compared to the large number of cases that need to be processed.

5. Resolving Property Rights - Investors often face difficulties in determining ownership over mostly a large number of small parcels and, as a consequence, in resolving property rights over land that is a condition for the realization of larger solar power plant projects. The causes are numerous, from the long-standing non-implementation of ownership changes by individuals in the process of inheritance or sale, but also incorrectly recorded data in the real estate cadastre.

In addition to the basic issues involved in implementing solar power plants in Serbia, there are problems related to the use of agricultural land for non-agricultural purposes, paying a large number of taxes during project realization, financing projects, the possibility of obtaining the status of a privileged producer, and similar issues. However, these delve into the realms of economics and agro-economics and would require a separate analysis that goes beyond the scope of this book’s topic.

Given that the expansion in the development of large solar power plants in Serbia began relatively recently (since 2021), it is not surprising that these key issues are gradually being recognized by all stakeholders in the process of implementing solar power plant projects. This is certainly encouraging for institutions, investors, experts, and for creating a better investment environment in the field of solar energy in Serbia.

3.UTICAJ SOLARNIH ELEKTRANA NA ŽIVOTNU SREDINU

Kao i razne razvojne aktivnosti, tako i solarne elektrane imaju ili mogu imati određene uticaje na životnu sredinu. Ti uticaji mogu biti i pozitivni i negativni. Da bi se govorilo o mogućim uticajima solarnih elektrana na životnu sredinu, potrebno je prethodno razumevanje koncepcije izgradnje i funkcionisanja solarnih elektrana.

3.1. Način funkcionisanja solarnih elektrana

Solarna energija se u solarnim elektranama dobija pomoću fotonaponskih solarnih panela. Fotonaponske panele karakteriše direktno generisanje električne energije iz sunčevih zraka preko solarnih ćelija. Princip funkcionisanja je takav da sunčevo zračenje ostvari kontakt s fotonaponskom solarnom ćelijom, fotoni svetlosti jonizuju poluprovodnički materijal (obično silicijum) u solarnoj ćeliji, što uzrokuje oslobađanje elektrona od atomskih veza i stvaranje električne struje, koja se zatim može ili usmeriti ka potrošačima preko prenosnog sistema ili skladištiti u bateriji.

Integracija više fotonaponskih solarnih panela u jedinstven funkcionalni sistem predstavlja solarnu elektranu (slika 14).

3. THE IMPACT OF SOLAR POWER PLANTS ON THE ENVIRONMENT

Like various developmental activities, solar power plants also have or can have certain impacts on the environment. These impacts can be both positive and negative. To discuss the potential impacts of solar power plants on the environment, it is necessary to first understand the concept of building and operating a solar power plant.

3.1. Operation of Solar Power Plants

Solar energy in solar power plants is used with the help of photovoltaic (PV) solar panels. Photovoltaic panels are characterized by the direct generation of electricity from sunlight through solar cells. The principle of operation is such that solar radiation makes contact with the photovoltaic solar cell, photons of light ionize the semiconductor material (usually silicon) in the solar cell, causing electrons to break free from their atomic bonds and create an electric current that can then be directed to consumers via the transmission system or stored in a battery.

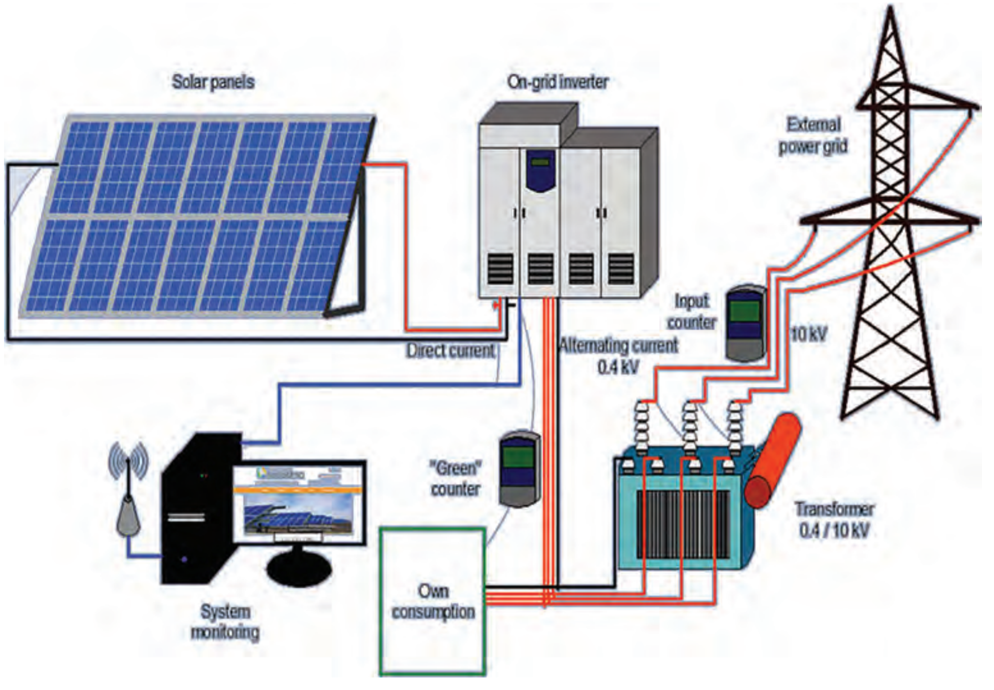
The integration of multiple photovoltaic solar panels into a single functional system constitutes a solar power plant (Figure 14).

Slika 14. Ilustrativni prikaz izgleda solarne elektrane (izvor: PVcase.com)

Figure 14. Illustration of a solar farm (Source: PVcase.com)

Ne ulazeći mnogo u tehničke detalje funkcionisanja solarne elektrane, treba ipak navesti njene osnovne elemente. To su: solarni paneli, interna kablovka mreža, transformatorska stanica i priključni dalekovodi (slika 15).

Without going into too many technical details of how a solar power plant operates, it is important to mention its basic elements. These include: solar panels, internal wiring network, transformer station, and connecting power lines (Figure 15).



Slika 15. Osnovni funkcionalni elementi solarne elektrane (izvor: Muhammad et al, 2020)

Figure 15. Basic functional elements of a solar power plant (Source: Muhammad et al, 2020)

Na osnovu ilustrativnog prikaza na slici 15 može se konstatovati da se kompleks solarne elektrane sastoji od infrastrukturnih objekata za proizvodnju električne energije (solarni paneli), objekata za prenos el. energije (unutrašnja kablovska mreža i trafostanica) i saobraćajnih objekata (interne pristupne saobraćajnice u funkciji izgradnje i održavanja solarne elektrane).

Svaki funkcionalni deo solarne elektrane ima svoju ulogu i poseban značaj u funkcionisanju sistema solarne elektrane, mada su u prostornom smislu najdominantniji solarni paneli. U zavisnosti od instalisane snage solarne elektrane, solarni paneli mogu zauzimati velike površine, zbog čega su oni posebno značajni sa aspekta mogućih uticaja na životnu sredinu, što je od posebnog značaja za temu ove knjige. Naime, danas se malim solarnim elektranama smatraju one čija je instalisana snaga do 10 MW i za čiju je realizaciju potrebno nešto više od 10 hektara zemljišta. Danas se u svetu, međutim, realizuju solarne elektrane od nekoliko stotina MW do čak nekoliko GW, koje zauzimaju stotine i hiljade hektara zemljišta. U tabeli 4 dat je spisak trenutno najvećih solarnih elektrana na svetu, od kojih su neke pojedinačne, dok neke predstavljaju jedinstven sistem većeg broja solarnih elektrana.

Based on the illustrative representation in Figure 15, it can be observed that the complex of a solar power plant consists of infrastructure for electricity production (solar panels), infrastructure for electricity transmission (internal wiring network and transformer station), and transportation infrastructure (internal access roads for construction and maintenance of the solar power plant).

Each of the functional parts of a solar power plant has its role and significance in the functioning of the solar power plant system, but the most dominant in space are the solar panels. Depending on the installed capacity of the solar power plant, the surfaces under the solar panels can occupy large areas, which makes them particularly significant in terms of potential environmental impacts, which is of special importance for the topic of this book. Namely, today small solar power plants are considered those with an installed capacity of up to 10 MW and for whose realization more than 10 hectares of land is required. However, today in the world, solar power plants with capacities of several hundred MW, up to several GW, are being realized, occupying hundreds and thousands of hectares of land. Table 4 lists the currently largest solar power plants in the world, some of which are individual, while others represent a unique system of a larger number of solar power plants.

Tabela 4. Spisak trenutno najvećih solarnih elektrana u svetu (izvor: energydigital.com)
Table 4. List of currently largest solar power plants in the world (Source: energydigital.com)

Naziv i lokacija projekta / Project name and location	**Instalisana snaga / Installed capacity**	**Opis / Description**
Golmud – Kina / China	2,8 GW	Sastoji se od 80 solarnih elektrana. Dovoljna je za napajanje preko milion domaćinstava. zgradnja je počela 2011. godine i završena je 2019. Godine. Koristi fotonaponsku (PV) tehnologiju, sa preko 7,2 miliona solarnih panela instaliranih za proizvodnju električne energije. / Consists of 80 solar power plants. It is sufficient to power over a million households. Construction began in 2011 and was completed in 2019. It uses photovoltaic (PV) technology, with over 7.2 million solar panels installed for electricity production.
Bhadla – Indija / India	2,7 GW	Zauzima površinu od 14.000 hektara, sa konstantnom proizvodnjom od 2,25 GW. / Covers an area of 14,000 hectares, with a constant production of 2.25 GW.
Pavagada – Indija / India	2,05 GW	Prostire se na 13.000 hektara. Razvoj projekta koštao je 2 milijarde dolara. Karnataka, država u kojoj se nalazi solarna elektrana ima najveći instalirani kapacitet solarne energije među indijskim državama. / Spread over 13,000 hectares. The project's development cost $2 billion. Karnataka, the state where the solar power plant is located, has the highest installed solar energy capacity among Indian states.
Benban – Egipat / Egypt	1,8 GW	Najveća solarna elektrana u Africi, sa potencijalom od 6,3 kWh/m^2 dnevno. Projektom od 1,8 GW upravlja Uprava za nove i obnovljive izvore energije (NREA), koja je u vlasništvu države. Uključuje niz malih solarnih elektrana koje grade različite kompanije. Projekat je deo Strategije održive energije egipatske vlade 2030./ The largest solar power plant in Africa, with a potential of 6.3 kWh/m2 daily. The 1.8 GW project is managed by the New and Renewable Energy Authority (NREA), owned by the state. It includes a series of small solar power plants built by various companies. The project is part of the Egyptian government's 2030 Sustainable Energy Strategy.
Mohammed Bin Rashid Al Maktoum – UAE	1,63 GW	Pustinjska država UAE dom je solarnog parka od 76 km^2, sa trenutnim kapacitetom od 1,63 GW I planom da poraste na 5 GW do 2030. godine. / The desert state of UAE is home to a 76 km2 solar park, with a current capacity of 1.63 GW and plans to grow to 5 GW by 2030.

Naziv i lokacija projekta / Project name and location	Instalisana snaga / Installed capacity	Opis / Description
Tengger – Kina / China	1,51 GW	Trenutno snabdeva oko 600.000 domaćinstava sa svojih 43 km^2 pod solarnim panelima. Kada bude u potpunosti operativna, njen godišnji rezultat snage će biti 5,78 milijardi kilovata, što je ekvivalent uštedi od 1,92 miliona tona standardnog uglja svake godine. Ovo je značajno za zemlju koja se u velikoj meri oslanja na ugalj za energiju./ Currently supplies around 600,000 households with its 43 km2 under solar panels. When fully operational, its annual power output will be 5.78 billion kilowatts, equivalent to saving 1.92 million tons of standard coal every year. This is significant for a country that relies heavily on coal for energy.
Noor Abu Dhabi – UAE	1,17 GW	Najveća svetska elektrana na jednom mestu, Noor Abu Dhabi, snabdeva energijom oko 90.000 domaćinstava. Ima 3,2 miliona solarnih panela. Proizvodi približno 1,2 GW električne energije, smanjujući zavisnost od prirodnog gasa za proizvodnju električne energije i smanjujući karbonski otisak u zemlji za 1 milion metričkih tona godišnje./ The largest single-site solar power plant in the world, Noor Abu Dhabi supplies energy to about 90,000 households. It has 3.2 million solar panels that produce approximately 1.2 GW of power, reducing dependence on natural gas for power generation and decreasing the country's carbon footprint by 1 million metric tons annually.
Jichuan – Kina / China	1 GW	Gotovo celi Jinchuan u kineskoj provinciji Gansu pokriven je solarnim elektranama. Solarna elektrana zauzima skoro 90 km^2 polupustinje zapadno od grada. Kompleks se sastoji od 15 elektrana./ Almost the entire Jinchuan in the Gansu province of China is covered by solar power plants. The solar power plant occupies nearly 90 km2 of semi-desert west of the city. The complex consists of 15 power plants.
Kurnool – Indija / India	1 GW	Smeštena na jugu Indije, s operativnim kapacitetom od 1 GW, što je značajan deo indijskog bruto instaliranog kapaciteta električne energije, solarna elektrana štedi procijenjenih 1.892.160 tona emisije CO_2./ Located in southern India, with an operational capacity of 1 GW, a significant part of India's gross installed capacity of electricity, the solar power plant saves an estimated 1,892,160 tons of CO2 emissions

Razmere zauzetog prostora za velike solarne elektrane prikazane u tabeli 4 zaista su impozantne, ali ih treba sagledavati i u kontekstu veličine teritorija država u kojima su realizovane i u kontekstu vrste i namene zemljišta koje zauzimaju. U svakom slučaju, nije isto ako se velike solarne elektrane realizuju na kvalitetnom poljoprivrednom zemljištu i ako se realizuju na pustinjskom, devastiranom ili nekorišćenom zemljištu.

U kontekstu zauzimanja zemljišta sa ekspanzijom solarne energetike na globalnom nivou, treba imati u vidu tehnološki napredak u proizvodnji solarnih panela koji perspektivno omogućava veću instalisanu snagu na manjem prostoru, što je sa aspekta uticaja solarnih elektrana na životnu sredinu svakako povoljan trend.

Jedan od načina realizacije i funkcionisanja solarnih elektrana jesu tzv. hibridne elektrane, u kojima se kombinuje korišćenje eolske i solarne energije (vetroelektrane i solarne elektrane). Predstavlja relativno novi trend u razvoju projekata koji koriste obnovljive izvore energije, koncipiran po principu veće energetske iskorišćenosti istog prostora.

3.2. Uticaji solarnih elektrana na životnu sredinu

S globalnom energetskom krizom vezani su i globalni ekološki problemi, odnosno ova dva problema danas se u svetu tretiraju kao jedno pitanje, koje je sadržano u konceptu dobijanja ekološki čiste

The scale of land occupied by large solar power plants shown in Table 4 is impressive, but it should be viewed in the context of the size of the territories of the countries in which they are realized, as well as in the context of the type/use of the land they occupy. In any case, it is not the same if large solar power plants are realized on quality agricultural land and if they are realized on desert, devastated, or unused land.

In the context of land occupation with the expansion of solar energy globally, it is important to consider technological advancements in solar panel production that prospectively enable higher installed capacity in smaller spaces, which is certainly a favourable trend from the perspective of the impact of solar power plants on the environment.

One way of realizing and operating solar power plants is within the so-called hybrid power plants, which combine the use of wind and solar energy (wind farms and solar power plants). It represents a particularly favourable approach to using renewable energy sources, given the advantages of renewable energy sources in reducing the emission of harmful gases and pollutants into the atmosphere and the advantages of wind energy, which is less dependent on climatic and geographic conditions compared to solar energy.

3.2. Influences of Solar Power Plants on the Environment

Global environmental issues are tightly bound with the global energy crisis, and these two issues are treated today as one question encapsulated in the concept of obtaining eco-friendly energy, also energije (tzv. zelene energije). Ekološke prednosti proizvodnje električne energije iz obnovljivih izvora, s jedne strane, i razvoj svesti stanovništva o potrebi zaštite životne sredine, s druge strane, predstavljaju dobar osnov za dinamičan razvoj projekata u oblasti primene ekološki čiste energije koja se bazira na primeni obnovljivih energetskih resursa. Tome svakako doprinosi i kontinuirani razvoj tehnologija u ovoj oblasti koji doprinose konkurentnosti ovakvih projekata na tržištu električne energije (Josimović and Pucar, 2010).

Proizvodnja električne energije na globalnom nivou, međutim, i dalje se u velikoj meri bazira na fosilnim gorivima, sa svim negativnim implikacijama koje ona nose sa sobom. To iscrpljuje prirodne resurse i degradira životnu sredinu, što predstavlja ozbiljne pretnje održivom razvoju (Adhikari et. al, 2008).

Dakle, pored ekonomskih benefita u oblasti energetike, sve je važniji ekološki aspekt, koji postaje dominantan uslov za očuvanje prostora i životne sredine, ali i za finansiranje projekata od strane međunarodnih finansijskih institucija (Josimović et al, 2021). Narušavanje prirode danas je postalo intenzivno, tako da se korišćenje obnovljivih izvora energije u današnje vreme nameće kao deo rešenja globalnog problema. Emisija gasova sa efektom staklene bašte najvećim delom su posledica sagorevanja fosilnih goriva (Josimović et al, 2023). Zelena energija, a samim tim i solarna energija, ublažavaju nastale posledice i doprinose da se priroda sama obnovi. Solarna energija je čista energija, bez emisije štetnih gasova i ispuštanja otpadnih voda.

Kako bi se negativni uticaji energetskog sektora na životnu sredinu smanjili

known as "green energy." The ecological advantages of generating electricity from renewable sources, on one hand, and the growing awareness of the need to protect the environment, on the other hand, provide a solid foundation for the dynamic development of projects in the field of eco-friendly energy application based on renewable energy resources. Continuous technological advancements in this field contribute to the competitiveness of such projects in the electricity market (Josimović and Pucar, 2010).

However, electricity production on a global scale still heavily relies on fossil fuels with all the negative implications it brings. This leads to the depletion of natural resources and environmental degradation, posing serious threats to sustainable development (Adhikari et al., 2008).

Therefore, alongside the economic benefits in the energy sector, the ecological aspect becomes increasingly important as a dominant condition for preserving space and the environment, as well as for financing projects by international financial institutions (Josimović et al., 2021). Environmental degradation has become intense today, making the use of renewable energy sources a part of the solution to the global problem. The emission of greenhouse gases is largely a result of burning fossil fuels (Josimović et al., 2023). Green energy, and consequently solar energy, mitigate the consequences and contribute to nature's own restoration. Solar energy is clean energy, with no emission of harmful gases or discharge of wastewater.

To mitigate the negative impacts of the energy sector on the environment while simultaneously generating income, which is an essential condition, investors and large a istovremeno ostvario prihod, što je neizostavan uslov, investitori i velike energetske kompanije odlučuju se za razvoj elektrana koje koriste obnovljive izvore. Razlog je, dakle, dvojak (Josimović et al 2023):

1. Izgradnja elektrana koje koriste obnovljive izvore energije ima ekološkog smisla, što je u skladu s razvojem svesti o značaju zaštite životne sredine, s jedne strane, i usklađivanjem s mnogobrojnim i značajnim međunarodnim sporazumima koji se tiču zaštite životne sredine i klimatskih promena, s druge strane. Svaki kWh električne energije proizveden korišćenjem obnovljivih energetskih resursa zamenjuje istu količinu energije koju bi s druge strane trebalo proizvesti u elektranama na fosilno gorivo, što ima za posledicu redukciju negativnih uticaja na životnu sredinu, a naročito emisije CO_2 u atmosferu (Esco, 2017). Analizom podataka emisije CO_2 pri proizvodnji električne energije iz različitih primarnih izvora može se zaključiti da su obnovljivi izvori energije u poređenju s fosilnim gorivima neuporedivo prihvatljiviji sa aspekta životne sredine;

2. proizvodnjom električne energije u elektranama koje koriste obnovljive energetske resurse ostvaruje se značajna dobit, koja je inicijalno morala da bude podstaknuta povlašćenom cenom koju investitori dobijaju od države kao podsticaj za ovakav vid proizvodnje električne energije. Razvojem tržišta u korišćenju obnovljivih izvora energije, odnosno padom cene opreme srazmerno sve većoj upotrebi obnovljivih energetskih resursa, ovi podsticaji su sve manje potrebni i investicije se usmeravaju po principima tržišne ekonomije.

Iako je sinonim za solarnu energiju čista tehnologija ili tzv. zelena energija, njihova

energy companies opt for the development of plants that utilize renewable sources. The rationale is twofold (Josimović et al., 2023):

1. Constructing plants that utilize renewable energy sources makes ecological sense, aligning with the growing awareness of environmental protection significance and compliance with numerous significant international agreements concerning environmental protection and climate change. Every kWh of electricity produced using renewable energy resources replaces the same amount of energy that would otherwise need to be produced in fossil fuel power plants, resulting in a reduction in negative environmental impacts, especially CO_2 emissions into the atmosphere (Esco, 2017). Analysing CO_2 emission data from electricity production from various primary sources reveals that renewable energy sources are incomparably more environmentally acceptable compared to fossil fuels;

2. Generating electricity in plants that utilize renewable energy resources yields significant profits, initially driven by the preferential price investors receive from the state as an incentive for this type of electricity production. With the development of the market in using renewable energy sources and the drop in equipment prices proportional to the increasing use of renewable energy resources, these incentives are becoming less necessary, and investments are directed towards market economy principles.

Although synonymous with solar energy is “clean technology” or so-called green energy, its realization entails dual impacts realizacija podrazumeva dvostruke uticaje na životnu sredinu – pozitivne i negativne. Pozitivni uticaji solarnih elektrana imaju širi kontekst koji se ostvaruje smanjenjem emisije gasova sa efektom staklene bašte u energetskom sektoru kroz smanjenje upotrebe fosilnih goriva. Negativni uticaji su uticaji koji nastaju tokom realizacije (izgradnje) solarne elektrane na određenoj lokaciji, tokom njenog funkcionisanja i nakon zatvaranja solarne elektrane. Namera autora je da sagleda obe vrste uticaja, odnosno da u svojim elaboracijama bude objektivan u odnosu na ovu temu. Pri tome će akcenat biti stavljen na analizu negativnih uticaja solarnih elektrana na životnu sredinu jer se oni javljaju na operativnom nivou, odnosno u toku planiranja, projektovanja, izgradnje i funkcionisanja. Naime, pozitivni uticaji su uvek poželjni i njih je uglavnom dovoljno samo konstatovati, dok negativni uticaji nisu poželjni, ali se može uticati na njihovu eliminaciju ili minimiziranje. Cilj ove knjige upravo i jeste identifikovanje i procena negativnih uticaja (prostornih/teritorijalnih) solarnih elektrana na životnu sredinu i prikaz načina na koji se ti negativni uticaji mogu umanjiti ili potpuno eliminisati (Josimović and Crnčević, 2012).

on the environment – both positive and negative. The positive impacts of solar power plants have a broader context, achieved by reducing greenhouse gas emissions in the energy sector through reducing the use of fossil fuels. The negative impacts arise during the realization (construction) of a solar power plant at a specific location, during its operation, and after the closure of the solar power plant. The author's intention is to examine both types of impacts objectively concerning this topic in their elaborations. The focus will be on analysing the negative impacts of solar power plants on the environment because they occur at the operational level, during planning, designing, construction, and operation. Namely, positive impacts are always desirable and usually only need to be stated, while negative impacts are undesirable, but efforts can be made to eliminate or minimize them. The aim of this book is precisely to identify and assess the negative impacts (spatial/territorial) of solar power plants on the environment and to present ways in which these negative impacts can be minimized or completely eliminated (Josimović and Crnčević, 2012).

3.2.1. Pozitivni efekti korišćenja energije sunca

Ekološke prednosti proizvodnje električne energije iz energije sunca i razvoj tehnologija u ovoj oblasti, u sve većoj meri omogućavaju i da razvoj solarne energetike bude dinamičan, posebno tokom poslednjih godina. To je posebno važno u vremenu sve većeg interesovanja za zaštitu životne sredine na globalnom, nacionalnom,

3.2.1. Positive Effects of Solar Energy Use

The ecological advantages of generating electricity from solar energy and the development of technologies in this field increasingly allow for dynamic development, especially in recent years. This is particularly important at a time of growing interest in environmental protection at the global, national, regional, and local levels. The importance of regionalnom i lokalnom nivou. Značaj zaštite životne sredine posebno je izražena u sektoru energetike kao jednom od najznačajnijih zagađivača. Porast broja stanovnika na planeti kao posledicu ima sve veće potrebe za energijom, zbog čega je upravo sektor energetike posebno interesantan za analizu mogućnosti smanjenja zagađenja životne sredine.

Kao što je prethodno navedeno, najznačajniji pozitivni uticaji solarnih elektrana na životnu sredinu moraju se sagledavati u širem kontekstu, koji prevazilazi pojedinačne projekte, lokalne ili regionalne, pa čak i nacionalne okvire, jer ima globalni značaj. To je svakako proizvodnja električne energije bez emisije zagađujućih materija u vazduh, uključujući gasove sa efektom staklene bašte. Ova činjenice je nesporna i ovaj pozitivni uticaj dugoročno i globalno ostvaruje izuzetan doprinos kvalitetu životne sredine. Kao što je ranije navedeno, svaki kW električne energije dobijene u solarnim elektranama u perspektivi utiče na smanjenje iste proizvedene snage iz tradicionalnih (neobnovljivih) energetskih izvora. To bi u bliskoj budućnosti trebalo da utiče na smanjenje potreba za energijom iz termoelektrana, odnosno na smanjenje zagađenja vazduha i emisije gasova sa efektom staklene bašte. Ako se ovakve pretpostavke ostvare, potpuno će biti opravdani razlozi zbog kojih su se elektrane koje koriste obnovljive izvore energije uključile u sektor energetike i postale njen sastavni deo. Imajući u vidu postojeće kapacitete u solarnim elektranama i dinamiku razvoja sektora solarne energetike na globalnom nivou, može se samo pretpostaviti koliki bi to značaj moglo imati u zaštiti životne sredine na planetarnom nivou.

environmental protection is particularly pronounced in the energy sector as one of the most significant polluters. The increasing population on the planet results in greater energy needs, making the energy sector especially interesting for analyzing possibilities to reduce environmental pollution.

As mentioned earlier, the most significant positive impacts of solar power plants on the environment must be viewed in a broader context, surpassing individual projects, local or regional frameworks, and even national frameworks, as they have global significance. This notably includes the production of electricity without emitting pollutants into the air, including greenhouse gases. This fact is undeniable and this positive impact makes an exceptional contribution to the long-term and global quality of the environment. As previously stated, every kW of electricity obtained in this way in solar power plants affects the reduction of the same power produced from traditional (non-renewable) energy sources. This is expected to lead to a decrease in energy needs from thermal power plants in the near future, thus reducing air pollution and greenhouse gas emissions. If these assumptions materialize, there will be fully justified reasons for including power plants that use renewable energy sources in the energy sector and making them an integral part of it. Considering the existing capacities in solar power plants and the dynamics of the solar energy sector's development globally, one can only imagine how significant this could be in environmental protection on a planetary scale.

However, a comprehensive assessment of these positive impacts by examining

Bilo bi, međutim, interesantno celovito sagledavanje ovih pozitivnih uticaja kroz životni ciklus projekta, odnosno raspolagati podacima o utrošku energije i eventualnim uticajima koje na životnu sredinu može imati eksploatacija i proizvodnja sirovina za izradu opreme koja se koristi u solarnin elektranama (pre svega solarnih panela), a zatim i izrada opreme za solarne elektrane, njen transport do lokacije na kojoj se postavlja, i dr. Takođe, tom prilikom bi se morali sagledati i uticaji koji nastaju nakon prestanka rada solarne elektrane, a kojima bi se takođe obuhvatio transport opreme s lokacije, njen tretman u određenim postrojenjima za reciklažu, itd. Svakako bi se prilikom takve analize došlo do određenih umanjenja pozitivnih uticaja solarnih elektrana na životnu sredinu. Tako bi se doprinelo konkretnijem utvrđivanju obima i značaja pozitivnih uticaja solarnih elektrana na životnu sredinu i klimatske promene.

Klimatske promene predstavljaju jedan od najozbiljnijih efekata upotrebe fosilnih goriva. Sagorevanjem fosilnih goriva oslobađaju se gasovi sa efektom staklene bašte. Rezultat je globalno zagrevanje i čitav niz implikacija koje to zagrevanje ima u odnosu na životnu sredinu i živi svet na planeti. Dobijanje električne energije korišćenjem energije Sunca u solarnim elektranama ne proizvodi gasove sa efektom staklene bašte i potencijalno je važan korak ka „stabilizaciji" klime. Da bi se ilustrovao ovakav scenario, dobra je prilika osvrnuti se na rezultate nedavne studije Nacionalne laboratorije za obnovljivu energiju SAD (National Renewable Energy Laboratory – NREL, 2015), u kojoj je zaključeno da će povećanje korišćenja obnovljivih izvora energije od 25% uticati na smanjenje emisije gasova sa efektom staklene bašte za 30%. Dakle, pozitivan

the project's life cycle, i.e., having data on energy consumption and potential impacts of the exploitation and production of raw materials for the equipment used in solar power plants (primarily solar panels), followed by the production of equipment for solar power plants, their transport to the installation location, etc., would be interesting. Likewise, such an analysis would need to consider the impacts arising after the solar power plant ceases operation, including equipment transport from the site, its treatment in certain recycling facilities, etc. Such an analysis would inevitably lead to some reduction in the positive impacts of solar power plants on the environment. This would contribute to a more concrete determination of the scope and significance of the positive impacts of solar power plants on the environment and climate change.

Climate change represents one of the most serious effects of fossil fuel use. Burning fossil fuels releases greenhouse gases. The result is global warming and a host of implications this warming has on the environment and life on the planet. Obtaining electricity using solar energy in solar power plants does not produce greenhouse gases and is potentially an important step towards "stabilizing" the climate. To illustrate such a scenario, it is useful to refer to the results of a recent study by the National Renewable Energy Laboratory (NREL) of the United States (National Renewable Energy Laboratory-NREL, 2015), which concluded that increasing the use of renewable energy sources by 25% would lead to a 30% reduction in greenhouse gas emissions. Therefore, the positive impact on slowing climate change is another significant and uticaj na usporavanje klimatskih promena još jedan je bitan i pozitivan uticaj korišćenja energije Sunca i obnovljivih izvora uopšte.

To je dalje povezano s pozitivnim uticajem na zdravlje ljudske populacije, ali i na druge oblike života i ukupan biodiverzitet na planeti.

Još jedna prednost korišćenja energije Sunca u solarnim elektranama u odnosu na korišćenje fosilnih goriva jeste energetska efikasnost. Naime, ekstrakcija i prerada fosilnih goriva je skupa. Pored toga, ogromne količine energije koriste se za transport fosilnih goriva sa udaljenih lokacija do mesta upotrebe. S druge strane, električna energije proizvedena solarnim elektranama efikasno se isporučuje prenosnim vodovima do mesta upotrebe, bez dodatne prerade, transporta i sl. Ovaj aspekt pozitivnog uticaja solarne elektrane na životnu sredinu takođe je rezultat komparacije sa elektranama koje koriste fosilna goriva.

3.2.2. Mogući negativni efekti pri izgradnji i eksploataciji solarnih elektrana

Pored nespornih pozitivnih uticja koje solarne elektrane imaju na životnu sredinu i klimatske promene, mogu se javiti i određeni negativni uticaji na prostor i pojedine činioce životne sredine. Zaobilazeći restriktivan, konzervatorski pristup zaštiti, po kom „ništa nije dozvoljeno", autorova namera je da u kontekstu primene principa održivog razvoja sagleda i potencijalne negativne uticaje solarnih elektrana na životnu sredinu i time doprinese objektivnim problemskim pristupom.

Na ovom mestu je važno istaći da prilikom utvrđivanja mogućih negativnih uticaja

positive effect of using solar energy and renewables in general.

This is further linked to the positive impact on the health of the human population, as well as on other forms of life in the overall biodiversity on the planet.

Another advantage of using solar energy in solar power plants compared to using fossil fuels is energy efficiency. Extracting and processing fossil fuels is expensive. Moreover, enormous amounts of energy are used to transport fossil fuels from distant locations to the point of use. On the other hand, electricity produced in solar power plants is efficiently delivered through transmission lines to the point of use, without additional processing, transport, etc. This aspect of the positive impact of solar power plants on the environment is also a result of comparison with power plants using fossil fuels.

3.2.2. Possible Negative Effects during Construction and Operation of Solar Power Plants

In addition to the undeniable positive impacts that solar power plants have on the environment and climate change, certain negative impacts on space and specific environmental factors may occur. Avoiding a restrictive conservation approach in which "nothing is allowed," the author intends to, within the context of sustainable development principles, examine potential negative impacts of solar power plants on the environment and thus contribute to an objective problem-solving approach.

It is important to emphasize that, when determining possible negative impacts of solarnih elektrana na životnu sredinu uvek treba imati u vidu koristi od realizacije ovakvih projekata u poređenju sa uticajima nekih drugih elektrana (posebno onih koje rade na fosilna goriva). Tako izvršena komparativna analiza upućuje na zaključak da su i određeni negativni uticaji solarnih elektrana na životnu sredinu relativni, jer ipak, u širem kontekstu, dovode do određenih pozitivnih trendova u životnoj sredini i energetici.

Solarne elektrane mogu implicirati različite negativne uticaje u zavisnosti od veličine projekta i specifičnosti lokacije na kojoj se planira njihova realizacija. Opšteprihvaćen stav je da su mogući negativni uticaji solarnih elektrana na životnu sredinu zanemarljivi u poređenju s pozitivnim efektima. Nikako ih, međutim, ne treba zanemariti. To se posebno odnosi na sledeće uticaje:

1. uticaj na zauzimanje zemljišta,

2. uticaj na biodiverzitet,

3. uticaj na predeo.

Pored navedenih dominantnih uticaja, značajno je spomenuti i druge manje privremene uticaje koji mogu nastati u toku izgradnje solarne elektrane, poput stvaranja buke i potencijalnog zagađenja osnovnih činilaca životne sredine, uticaja na nepokretna kulturna dobra, ali i uticaja koji nastaju u kontekstu stvaranja otpada od solarnih panela koji su oštećeni ili čiji je radni vek završen. Autor se u ovoj knjizi neće baviti ovakvim uticajima jer oni nemaju kontinuirani i strateški značajan teritorijalni uticaj.

3.2.2.1. Uticaj na zauzimanje zemljišta

Pri valorizaciji neke tehnologije bitan parametar je neophodno zemljište za njenu primenu. Sistem za funkcionisanje termoelektrana, na primer, iziskuje velike površine zemljišta za eksploataciju

solar power plants on the environment, one should always consider the benefits of realizing such projects compared to the impacts of other power plants (especially those operating on fossil fuels). Such a comparative analysis suggests that certain negative impacts of solar power plants on the environment are relative because, in a broader context, they lead to certain positive environmental and energy trends.

Solar power plants can imply various negative impacts depending on the project size and the specific location where they are planned to be realized. The generally accepted view is that the possible negative impacts of solar power plants on the environment are negligible compared to the positive effects. However, they should by no means be overlooked. This particularly applies to the following impacts:

1. Impact on land use,

2. Impact on biodiversity,

3. Impact on the landscape.

Among the mentioned dominant influences, it is significant to mention other minor temporary influences that may arise during the construction of a solar power plant, such as noise generation and potential pollution of essential environmental factors, impacts on immovable cultural assets, as well as impacts arising in the context of waste generation from solar panels that are damaged or at the end of their service life. The author of this book will not address such influences as they do not have continuous and strategically significant territorial influence.

3.2.2.1 Impact on Land Use

In the evaluation of any technology, an important parameter is the necessary land for its implementation. The operation of thermal power plants, for example, requires large land areas for: raw material sirovina, objekte, deponovanje otpada itd. Kod hidroelektrana pribranskog tipa, velike površine zemljišta, često i najplodnijeg, potapaju se i bivaju izgubljene za poljoprivredu. Kad je reč o vetroelektranama, situacija je umnogome drugačija. Vetrogeneratori se postavljaju na velikim visinama od tla (obično preko 100 m), što omogućava višenamensku upotrebu zemljišta na lokacijama na kojima se postavljaju. Uobičajeni primer je poljoprivreda. Na mnogim lokacijama u svetu vetoragregati se postavljaju na poljoprivrednom zemljištu i pašnjacima, koji se nakon izgradnje vetroelektrane i dalje nesmetano koriste za istu namenu. To omogućava izuzetnu ekonomičnost po pitanju iskorišćenosti zemljišta, gde se čak 99% zemljišta na području vetroelektrane može koristiti za poljoprivrednu proizvodnju za vreme njene eksploatacije (Josimović et al, 2023a).

Kad se govori o solarnim elektranama, zemljište koje se zauzima u direktnoj je korelaciji s veličinom (instalisanom snagom) solarnih elektrana. Zauzeće zemljišta odnosi se na prostor pod solarnim panelima, pa velike solarne elektrane mogu zauzimati velike površine, što je elaborirano u poglavlju 3.1.

Ukoliko se zauzimaju površine koje su devastirane (kamenolomi ili površine na kojima su se u prošlosti odvijale rudarske aktivnosti) ili neupotrebljive za neku drugu ljudsku aktivnost (pustinjski predeli ili neplodna zemljišta), ovakav uticaj nije od velikog značaja. Ukoliko se radi o kvalitetnom poljoprivrednom zemljištu, livadama, pašnjacima i drugim vrednim područjima, ovaj uticaj pak može imati presudan značaj.

U kontekstu navedenih stavova i nalaženja održivih rešenja, posebno je značajan optimalan izbor lokacije solarne elektrane, pri čemu važnu ulogu ima planski proces. Pored toga, moguća su i određena

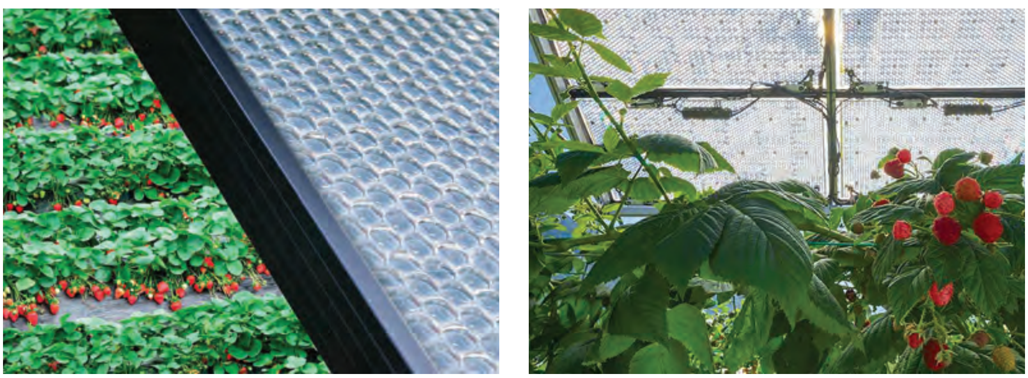
extraction; facilities; waste disposal, etc. In the case of reservoir-type hydroelectric power plants, large land areas, often the most fertile, are often submerged and lost to agriculture. When it comes to wind farms, the situation is quite different. Wind turbines are installed at great heights above the ground (usually over 100m), allowing for multi-purpose land use at the locations where they are installed. A common example is agriculture. In many locations worldwide, wind turbines are installed on agricultural land and pastures, which continue to be used for the same purpose after the wind farm is built. This allows for exceptional land use efficiency, enabling up to 99% of the land within the wind farm area to be used for agricultural production during its operation (Josimović et al., 2023a).

When it comes to solar power plants, the land occupancy is directly correlated with the size (installed capacity) of the solar power plants. Land occupation refers to the area under the solar panels, so large solar power plants can occupy large areas, as elaborated in Chapter 3.1.

If areas that are devastated (quarries or areas where mining activities took place in the past) or unusable for other human activities (desert areas or infertile lands) are occupied, such an impact is not of great significance. However, if it concerns quality agricultural land, meadows, pastures, and other valuable areas, this impact can be crucial.

In the context of the aforementioned views and in the context of finding sustainable solutions, the optimal selection of a solar power plant location is particularly significant, with the planning process playing an important role. In addition, koncepcijska rešenja, koja mogu uticati na relativizaciju problema zauzimanja kvalitetnijeg zemljišta za realizaciju solarnih elektrana. Primer su tzv. agrosolarne elektrane, koje pored korišćenja solarne energije obezbeđuju nastavak korišćenja zemljišta u poljoprivredne svrhe, što je poznata praksa u razvijenim i ekološki orijentisanim državama. U okviru solarne elektrane, solarni paneli se postavljaju na konstrukciju izdignutu na visinu dovoljnu za obrađivanje i održavanje biljaka ispod njih, uz postizanje optimalnog ugla za prijem sunčeve energije i transformaciju u električnu energiju. Prednosti agrosolarnih elektrana, pored izbegavanja prenamene poljoprivrednog zemljišta, jeste što pružaju i druge prednosti za gajene poljoprivredne kulture: nema direktnog svetla, postoji specifičan mikroklimatski efekat, zaštita od grada, smanjena evapotranspiracija, veća efikasnost vode. Na taj način se povećavaju prinosi, uz istovremeno smanjenje ugljeničnog otiska poljoprivrede. Ilustrativni prikaz agrosolarne elektrane dat je na slici 16.

certain conceptual solutions that can influence the relativization of the problem of occupying higher-quality land for the implementation of solar power plants are possible. An example is the so-called agrosolar power plants, which, in addition to using solar energy, ensure the continuation of land use for agricultural purposes, which is a well-known practice in developed and environmentally oriented countries. Within a solar power plant, solar panels are mounted on a structure raised to a height sufficient for cultivation and maintenance of plants underneath them, while achieving the optimal angle for receiving solar energy and transforming it into electrical energy. The advantages of agrosolar power plants, apart from avoiding the conversion of agricultural land, include achieving other benefits for cultivated agricultural crops: no direct sunlight, a specific microclimate effect, protection from hail, reduced evapotranspiration, greater water efficiency. In this way, yields are increased, while simultaneously reducing the carbon footprint of agriculture. An illustrative depiction of an agrosolar power plant is shown in Figure 16.



Slika 16. Ilustrativni prikaz gajenja malina i jagoda u agrosolarnoj elektrani (izvor: Izveštaj strateškoj proceni uticaja agrosolarnog projekta „Agrosolar Kula" na životnu sredinu, 2024)

Figure 16. Illustrative depiction of raspberry cultivation in an agrosolar power plant (Source: Report on the Strategic Environmental Impact Assessment of the "Agrosolar Kula" Project, 2024)

Pored navedenog, u agrosolarnim elektranama obično se ne predviđa upotreba pesticida, herbicida, đubriva i drugih toksičnih materija koje zagađuju zemljište i vodu. Na taj način se pomaže zemlji da se vrati u mikrobiološki obnovljeno, pa čak nekad i u organsko stanje, čime time se povećava vrednost zemljišta. Ilustrativno, solarni paneli mogu biti organizovani u više mikrocelina, između kojih se ostavljaju koridori za neometanu poljoprivrednu proizvodnju i manevar poljoprivredne mehanizacije (slika 17).

Efikasnost solarnog panela zavisi od meteoroloških prilika, koje u ekstremnim uslovima mogu dobiti toplotu stresa. Naime, kako se temperatura panela povećava, solarna efikasnost se smanjuje. Vegetacija oko i ispod solarnih panela (slika 18) pomaže u rashlađivanju sistema i omogućava veću proizvodnju energije (+ 3%).

Apart from the above, agrosolar power plants usually do not involve the use of pesticides, herbicides, fertilizers, and other toxic substances that pollute the soil and water. This helps the soil return to microbiologically renewed, and sometimes even organic, state, thereby increasing the value of the land. Illustratively, solar panels can be organized into multiple microcells, with corridors left between them for unhindered agricultural production and maneuvering of agricultural machinery (Figure 17).

The efficiency of solar panels depends on meteorological conditions, which under extreme conditions can lead to heat stress. Namely, as the temperature of the panels increases, solar efficiency decreases. Vegetation around and underneath solar panels (Figure 18) helps maintain system cooling and allows for greater energy production (+ 3%).

Slika 17. Ilustrativni prikaz funkcionisanja poljoprivredne mehanizacije na agrosolarnoj elektrani (izvor: Izveštaj o strateškoj proceni uticaja agrosolarnog projekta „Agrosolar Kula" na životnu sredinu, 2024)

Figure 17. illustrative depiction of the operation of agricultural machinery on an agrosolar farm (Source: Report on the Strategic Environmental Impact Assessment of the «Agrosolar Kula» Project, 2024)

Slika 18. Ilustrativni prikaz gajenja poljoprivrednih kultura u agrosolarnoj elektrani (izvor: Izveštaj o strateškoj proceni uticaja agrosolarnog projekta „Agrosolar Kula” na životnu sredinu, 2024)
Figure 18. Illustrative depiction of crop cultivation in an agrosolar power plant (Source: Report on the Strategic Environmental Impact Assessment of the "Agrosolar Kula" Project, 2024)

3.2.2.2. Uticaj na biodiverzitet

Veliki broj međunarodnih sporazuma, uz još neke koji na ovom mestu nisu navedeni, ukazuju na izuzetan (međunarodni) značaj zaštite biodiverziteta, bez obzira na vrstu projekata. Neki međunarodni sporazumi koje treba spomenuti jesu:

- *Konvencija o očuvanju migratornih vrsta divljih životinja – Bonska konvencija* odnosi se na migratorne vrste i na one koje redovno prelaze međudržavne (administrativne) granice. Propisuje združeno delovanje svih zemalja u čijim granicama migratorne vrste provode makar deo svog životnog ciklusa, jer prepoznaje da ugrožene migratorne vrste mogu biti odgovarajuće zaštićene samo ako se zaštitne mere sprovode na celom migratornom putu vrste (Zakon o potvrđivanju Konvencije o očuvanju migratornih vrsta divljih životinja – Bonska konvencija, „Službeni glasnik RS”, broj 102/2007);

3.2.2.2. Impact on Biodiversity

A large number of international agreements, along with some not mentioned here, indicate exceptional (international) significance of biodiversity conservation, regardless of the type of projects involved. Some of the international agreements worth mentioning are:

- Convention on the Conservation of Migratory Species of Wild Animals – Bonn Convention, concerning migratory species and those that regularly cross inter-state (administrative) boundaries. It prescribes joint action by all countries within whose borders migratory species spend at least part of their life cycle because it recognizes that endangered migratory species can be adequately protected only if protective measures are implemented along the entire migratory route of the species (Law on Ratification of the Convention on the Conservation of Migratory Species of Wild Animals Convention, "Official Gazette of RS", No. 102/2007).

- *Konvencija o očuvanju evropske divlje flore i faune i prirodnih staništa – Bernska konvencija* odnosi se na očuvanje i zaštitu biljnih i životinjskih vrsta u prirodi i njihovih prirodnih staništa, naročito onih čija zaštita iziskuje međunarodnu saradnju (Zakon o potvrđivanju Konvencije o očuvanju evropske divlje flore i faune i prirodnih staništa – Bernska konvencija, „Službeni glasnik RS", broj 102/2007);
- *Konvencija o biološkoj raznovrsnosti – Rio konvencija* obavezuje sve potpisnike da preduzmu mere rehabilitacije i obnove degradiranih ekosistema, promovišu oporavak ugroženih vrsta, doprinose razvoju i implementaciji planova i drugih strategija upravljanja radi očuvanja i održivog korišćenja biološkog diverziteta (Zakon o potvrđivanju Konvencije o biološkoj raznovrsnosti – Rio konvencija, „Službeni list SRJ", broj 11/2001).

Kad je reč o solarnim elektranama i njihovom uticaju na biodiverzitet, on se pre svega odnosi na eventualno ugrožavanje staništa, odnosno na potencijalnu izmenu staništa i uslova koji na njima postoje, kao i na izmenu karakteristika lovnih teritorija divljih vrsta koja koriste te teritorije. Naime, izmena jednog elementa utiče na izmenu drugog. U konkretnom slučaju, namenska izmena ili uklanjanje određenih npr. florističkih sastojina na lokaciji na kojoj se planira realizacija solarne elektrane direktno utiče na izmenu navika i ponašanja određenih jedinki faune na toj lokaciji. U tom kontekstu, od posebnog je značaja primena principa preventivne zaštite, koja podrazumeva optimalno planiranje i izbor lokacije solarne elektrane, čime se mogu

- Convention on the Conservation of European Wildlife and Natural Habitats – Bern Convention concerns the conservation and protection of plant and animal species in nature and their natural habitats, especially those whose protection requires international cooperation (Law on Ratification of the Convention on the Conservation of European Wildlife and Natural Habitats – Bern Convention, "Official Gazette of RS", No. 102/2007).
- Convention on Biological Diversity – Rio Convention obliges all signatories to take measures for the rehabilitation and restoration of degraded ecosystems, promote the recovery of endangered species, contribute to the development and implementation of plans and other management strategies for the conservation and sustainable use of biological diversity. (Law on Ratification of the Convention on Biological Diversity – Rio Convention, "Official Gazette of FR Yugoslavia", No. 11/2001).

When it comes to solar power plants and their impact on biodiversity, it primarily concerns the potential endangerment of habitats, i.e., the potential alteration of habitats and the conditions that exist on them, as well as the alteration of the characteristics of hunting territories of wild species that use those territories. Namely, the alteration of one element affects the alteration of another. In the specific case, the deliberate alteration or removal of certain, for example, floristic components at the location where the implementation of a solar power plant is planned directly affects the alteration of the habits and behaviours of certain fauna individuals at that location. In this context, the application of the principle of preventive protection potpuno eliminisati ili maksimalno umanjiti potencijalni uticaji na biodiverzitet.

U cilju preventivne zaštite biodiverziteta (staništa, flora i fauna) na prostoru buduće solarne elektrane, neophodno je optimalno mikrolociranje solarnih panela, koje se bazira na detaljnim kontinuiranim opservacijama biodiverziteta, čije se trajanje (obično godinu dana) utvrđuje u konsultacijama s relevantnim institucijama za zaštitu prirode. Osim identifikacije tipova staništa, vrsta flore i faune, njihovog značaja, brojnosti i navika, na osnovu ovih opservacija moguće je optimalno planiranje rasporeda zona i mikrolokacija za solarne panele u okviru solarne elektrane.

S druge strane, interesantno je istraživanje koje je objavila grupa naučnika iz Slovačke akademije nauka, Muzeja Gemer-Malohont, sa Univerziteta Komenski u Bratislavi, Katoličkog univerziteta u Ružomberoku, iz organizacije *BirdLife Slovakia* i s belgijskog Univerziteta u Antverpenu, u studiji „Solarni parkovi doprinose raznolikosti ptica u poljoprivrednom pejzažu" (Jarčuška et al, 2024). Istraživanje je pokazalo da solarne elektrane mogu imati i pozitivnu ulogu u promovisanju biodiverziteta, pre svega ptica, u poljoprivrednim predelima Centralne Evrope jer nude dostupnost hrane i mesta za gnežđenje. Analizirali su 32 parcele u okviru solarnih elektrana i 32 susedne kontrolne parcele u Slovačkoj tokom jedne sezone razmnožavanja. Tokom istraživanja, u solarnim elektranama uočene su 353 jedinke 41 vrste, a na kontrolnim parcelama 271 jedinka 40 vrsta. Prema mišljenju istraživača, bogatstvo vrsta ptica, raznovrsnost i brojnost vrsta koje jedu beskičmenjake, veći su u solarnim elektranama nego na kontrolnim

is of particular importance, which implies optimal planning and selection of the location of a solar power plant, which can completely eliminate or minimize potential impacts on biodiversity.

In order to provide preventive protection for biodiversity (habitats, flora, and fauna) in the area of the future solar power plant, it is essential to optimally micro-locate solar panels based on detailed and continuous observations of biodiversity. The duration of these observations (usually one year) is determined in consultation with relevant nature protection institutions. Based on these observations, which include the identification of types of habitats, species of flora and fauna, their significance, abundance, and habits, it is possible to optimally plan the layout of zones and micro-locations for solar panels within the solar power plant.

On the other hand, an interesting study conducted by a group of scientists from the Slovak Academy of Sciences, the Gemer-Malohont Museum, Comenius University in Bratislava, the Catholic University in Ružomberok, BirdLife Slovakia, and the University of Antwerp in Belgium was published in the study "Solar Parks Can Enhance Bird Diversity in Agricultural Landscape" (Jarčuška B. et al, 2024). The research showed that solar power plants can play a positive role in promoting biodiversity, particularly birds, in the agricultural landscapes of Central Europe because they offer food availability and nesting sites. They analysed 32 plots within solar power plants and 32 adjacent control plots in Slovakia during one breeding season. During the study, 353 individuals from 41 species were observed in the solar power plants and 271 individuals from 40 species in the control plots. According to the researchers, the richness of bird species, diversity, and abundance parcelama. Među razlozima koje je navela istraživačka grupa jeste dostupnost hrane za ptice insektojede, pošto solarni paneli privlače različite vrste vodenih insekata koji traže vodu. S obzirom na to da je dostupnost hrane niska zimi, može se pretpostaviti da solarne elektrane mogu imati pozitivan uticaj na ptice na poljoprivrednom zemljištu van sezone gnežđenja, jer mogu poslužiti kao mesta za zaustavljanje, ishranu i prenoćište tokom migracije i zimovanja, jer tlo ispod solarnih panela često bude bez snega zimi. Uočeno je takođe da su se određene vrste ptica gnezdile u potpornim konstrukcijama solarnih panela napravljenim od cevi ili u neobrađenim ili prostranim vegetacijama ispod solarnih panela ili pored ograde. U istraživanju je naglašeno da su solarne elektrane koje su korišćene u istraživanju koncipirane samo za proizvodnju električne energije, a da bi koristi za biodiverzitet bile još veće ako bi se njima upravljalo sinergijski, sa snažnijim fokusom na biodiverzitet.

U svakom slučaju, bilo da se radi o predikcijama pozitivnih ili negativnih uticaja solarnih elektrana na biodiverzitet, optimalan izbor lokacije, kroz planski proces, čini se kao posebno važan činilac u razvoju solarnih elektrana na principima preventivne zaštite biodiverziteta i prostora uopšte.

3.2.2.3. Uticaj na predeo

Predeone karakteristike predstavljaju subjektivnu kategoriju koju nije jednostavno kvantitativno oceniti. Vizuelni uticaj na okolinu predstavlja subjektivan utisak, koji osim od percepcije posmatrača zavisi i od tipa predela i specifičnih vizuelnih karakteristika (Josimović and Crnčević, 2012).

of species that feed on invertebrates were higher in solar power plants than in control plots. Among the reasons cited by the research group is the availability of food for insect-eating birds, as solar panels attract various species of aquatic insects that seek water. Since food availability is low in winter, it can be assumed that solar power plants can have a positive impact on birds in agricultural land outside the breeding season, as they can serve as stopping places, feeding grounds, and overnight shelters during migration and wintering because the ground under solar panels is often snow-free in winter. It was also observed that certain bird species nested in the support structures of solar panels made of pipes, or in unprocessed or spacious vegetation under solar panels or next to fences. The study emphasized that the solar power plants used in the study are designed solely for electricity production, and the benefits for biodiversity would be even greater if they were managed synergistically with a stronger focus on biodiversity.

In any case, whether it is about predicting the positive or negative impacts of solar power plants on biodiversity, optimal site selection, through a planned process, seems to be a particularly important factor in the development of solar power plants based on the principles of preventive biodiversity protection and space in general.

3.2.2.3. Impact on the Landscape

Landscape characteristics represent a subjective category that is not easy to quantitatively evaluate. The visual impact on the environment is a subjective impression that depends not only on the observer's perception but also on the type of landscape and specific visual characteristics (Josimović and Crnčević, 2012).

Predeo je veoma bogat i složen koncept, pa njegovo definisanje nije lak zadatak, što je evidentno iz velikog broja definicija koje postoje u različitim oblastima, poput umetnosti, geografije, prirodnih nauka, arhitekture ili ekonomije. Prema Evropskoj konvenciji o predelu (European Landscape Convention, 2000), predeo označava područje čiji je karakter rezultat akcije i interakcije prirodnih odnosno antropogenih faktora. Predeli nisu statični jer se menjaju tokom vremena u odnosu na antropogeni i ekološki razvoj.

Kad govorimo o predelu, ne mislimo dakle samo na prirodne vrednosti, već i na kulturne vrednosti određenog prostora (Dobričić et al, 2016; Dobričić et al, 2017; Dobričić and Josimović, 2018).

Velike solarne elektrane često dominiraju određenim prostorom, što je konstatovano i prikazano u tabeli 4 (poglavlje 3.1). Mogu zauzimati velike površine i potpuno izmeniti predeone karakteristike prostora na kom se nalaze. Zbog toga se s pravom može konstatovati da solarne elektrane u znatnoj meri utiču na predeo. Taj uticaj za posmatrača pak može biti pozitivan jer daje specifičan vizuelni identitet prostoru, dok će za drugog posmatrača vizuelni uticaj biti negativan jer menja izgled prirodnih predela. U tom kontekstu, vidljivost solarnih elektrana i njihov uticaj na predeo jedan je od subjektivnih kategorija.

I u ovom delu knjige potrebno je da se osvrnemo na uticaj drugih energetskih projekata na predeo, jer svaki od njih implicira ovaj uticaj. Tako, na primer, površinski kopovi koji su u funkciji termoelektrana imaju potpuno devastirajući uticaj na predeo, bez mogućnost

The landscape is a very rich and complex concept, so its definition is not an easy task, as evidenced by the large number of definitions in various fields such as art, geography, natural sciences, architecture, or economics. According to the European Landscape Convention (European Landscape Convention, 2000), the landscape denotes an area whose character is the result of the action and interaction of natural and/or anthropogenic factors. Landscapes are not static as they change over time in relation to anthropogenic and ecological development.

When we talk about the landscape, we do not mean only the natural values but also the cultural values of a certain area (Dobričić et al, 2016; Dobričić et al, 2017; Dobričić and Josimović, 2018).

Large solar power plants can often dominate a certain area, as stated and shown in table 4 (chapter 3.1). They can occupy large areas and completely change the landscape characteristics of the area on which they are located. Therefore, it can be rightly stated that solar power plants significantly affect the landscape. However, this impact may be positive for the observer because it gives a specific visual identity to the space, while for another observer, the visual impact may be negative because it alters the appearance of natural landscapes. In this context, the visibility of solar power plants and their impact on the landscape are subjective categories.

In this part of the book, it is necessary to also consider the impact of other energy projects on the landscape because each of them implies this impact. For example, surface mines that function as thermal power plants have a completely devastating impact on the landscape, without the possibility of a positive subjective pozitivne subjektivne ocene. Pribranske hidroelektrane takođe menjaju predeo, ali se formiranje akumulacionog jezera na uzvodnom delu brane obično tretira kao pozitivan uticaj na predeo zbog umirujućeg efekta vode na ljudsku percepciju i psihu. Dalje, obim vizuelnog uticaja vetroturbina u vetroelektrani obično pokriva široko područje i tako implicira značajniji uticaj na predeo.

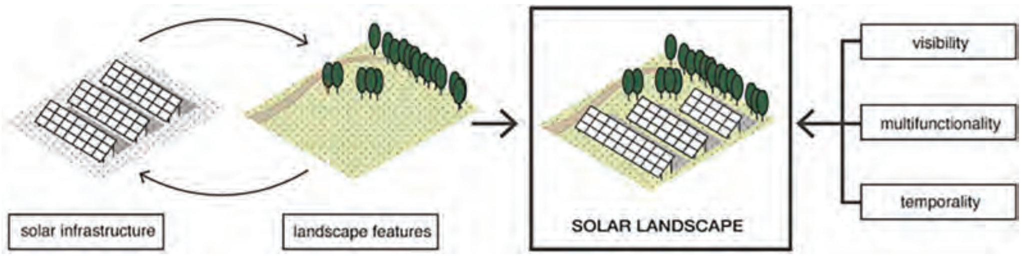
U poređenju s navedenim energetskim objektima, solarne elektrane ipak imaju manje uticaja jer su diskretne u prostoru, bez visokih elemenata. Zbog toga se optimalnim izborom lokacije solarne elektrane najviše može kontrolisati uticaj na predeo, ako pravimo komparaciju s drugim energetskim objektima.

Danas se u literaturi ukazuje na transformaciju predela prilikom realizacije solarnih elektrana i predlaže se rešavanje ovog problema kombinovanim prostornim rasporedom solarne elektrane i predela u tzv. solarnom pejzažu (Oudes and Stremke, 2021). Solarni pejzaži imaju zajednički cilj da se postignu druge koristi (npr. smanjenje vidljivosti, stvaranje staništa) pored proizvodnje električne energije. Naglašava se potreba za rešavanjem novih kompromisa između predeonih karakteristika i različitih tipova solarnih pejzaža (slika 19).

assessment. Reservoir hydroelectric power plants also change the landscape, but the formation of a reservoir lake on the upstream side of the dam is usually treated as a positive impact on the landscape due to the calming effect of water on human perception and psyche. Furthermore, the extent of the visual impact of wind turbines in wind farms usually covers a wide area and thus implies a more significant impact on the landscape.

In comparison with the aforementioned energy facilities, solar power plants still have fewer impacts because they are discreet in space, without elements that are tall. Therefore, the optimal choice of location for solar power plants can most effectively control the impact on the landscape, compared to other energy facilities.

Today, literature (Oudes and Stremke, 2021) indicates the transformation of the landscape during the realization of solar power plants and proposes solving this problem with a combined spatial arrangement of solar power plants and landscapes in the so-called solar landscape. Solar landscapes have a common goal to achieve other benefits (e.g., reduced visibility, habitat creation) besides electricity production. There is an emphasis on the need to address new compromises between landscape characteristics and different types of solar landscapes (Figure 19).



Slika 19. Ilustrativni prikaz kreiranja solarnog pejzaža (izvor: Oudes and Stremke, 2021)

Figure 19. Illustrative depiction of creating a solar landscape (source: Oudes and Stremke, 2021)

Neka istraživanja ukazuju na značaj socijalnog aspekta sagledavanja uticaja solarne elektrane na predeo (Ko, 2023). Naime, povećanje broja solarnih elektrana u Južnoj Koreji u protekloj deceniji uticalo je na više od polovine uprava okruga da usvoje restrikcije za solarne elektrane. Ova ograničenja deluju prilično restriktivno jer smanjuju raspoloživo zemljište za postavljanje solarnih elektrana, umanjujući doprinose dekarbonizaciji. Istraživanje implicira da se razvoj solarnih elektrana na nacionalnom nivou može suočiti sa preprekama lokalne zajednice ukoliko ne postoji racionalna i ravnomerna prostorna raspodela razvojnih projekata u oblasti solarne energetike, jer u suprotnom može doći do radikalnih uticaja na predeo i radikalnog odnosa prema razvoju solarnih elektrana na određenom prostoru. To svakako treba imati u vidu prilikom planiranja prostora.

Postoje različiti pristupi u analizi i proceni uticaja solarnih elektrana na predeo, ali se većina autora slaže u tome da se procena mora vršiti različitim instrumentima, modelima i metodama za simuliranje i vizuelizaciju mogućih uticaja, bilo da se radi o vetroelektranama (Mirasgedis et al, 2014;

Some studies (Ko, 2023) point out the importance of the social aspect of considering the impact of solar power plants on the landscape. Namely, with the increase in the number of solar power plants in South Korea in the past decade, more than half of county governments have adopted restrictions for solar power plants. These restrictions act quite restrictively as they reduce the available land for installing solar power plants, reducing contributions to decarbonization. The research implies that the development of solar power plants at the national level may face obstacles from the local community if there is no rational and even spatial distribution of development projects in the field of solar energy, as otherwise, there may be radical impacts on the landscape, and a radical approach to the development of solar power plants in a certain area. This should certainly be taken into account when planning space.

There are different approaches in the analysis and assessment of the impact of solar power plants on the landscape, but most authors agree that the assessment must be made using various instruments, models, and methods for simulating and visualizing possible impacts, whether it is wind farms (Mirasgedis et al, 2014;

Latinopoulos and Kechagia, 2016; Grieken and Dower, 2017; itd.), solarnim ili nekim drugim elektranama. U tom kontekstu mogu se koristiti različiti softverski modeli, GIS tehnologije, fotomontaža i druge metode pomoću kojih je moguće izvršiti predikcije o uticajima planirane solarne elektrane na na predeo, odnosno vizuelizovati i simulirati vidljivost solarne elektrane pre nego što se ona realizuje u konkretnom prostoru.

3.3. Instrumenti za zaštitu životne sredine pri planiranju i projektovanju solarnih elektrana

Danas je u upotrebi veliki broj različitih instrumenata za procenu uticaja planova, programa, strategija, politika i projekata na životnu sredinu.

Pojedini instrumenti, poput tradicionalne Procene uticaja životnog ciklusa (Life Cycle Assessment – LCA), daju sveobuhvatan pregled na razvoj projekta ili dobijanje finalnog proizvoda od ekstrakcije sirovina, preko prerade materijala, proizvodnje, distribucije, korišćenja, popravke i održavanja, do odlaganja odnosno recikliranja kao završne faze, koja se sprovodi nakon eksploatacionog perioda. Ideja je da se sagleda utrošak energije koja se koristi u nastanku nekog proizvoda u odnosu na vreme koje je potrebno da se ta energija „vrati" u procesu rada, odnosno eksploatacije. U slučaju solarnih elektrana, to bi značilo kvantifikovanje svih uticaja u opsegu korišćenja energije za izgradnju solarne elektrane (kumulativni efekat) i mogućnost da se ta energija u što kraćem roku ponovo proizvede. Zadatak LCA jeste da pokaže da određena tehnologija i projekat proizvode više energije nego što troše, jer u suprotnom ne bi postojao korisni doprinos solarne elektrane energetskom sistemu.

Latinopoulos and Kechagia, 2016; Grieken and Dower, 2017; etc.), or solar or other power plants. In this context, various software models, GIS technologies, photomontages, and other methods can be used to make predictions about the impacts of the planned solar power plant on the landscape, i.e., visualize and simulate the visibility of the solar power plant before it is implemented in a specific area.

3.3. Environmental Protection Instruments in Solar Power Plant Planning and Design

Today, a large number of different instruments are used to assess the impacts of plans, programs, strategies, policies, and projects on the environment.

Certain instruments, such as the traditional Life Cycle Assessment (LCA), provide a comprehensive overview of a project's development or the production of a final product from the extraction of raw materials, through material processing, production, distribution, use, repair, and maintenance, to disposal and/or recycling as the final stages carried out after the operational period. The idea is to evaluate the energy consumption involved in the creation of a product in relation to the time it takes for that energy to be "returned" during the operational or exploitation process. In the case of solar power plants, this would mean quantifying all impacts within the scope of using energy to build the solar power plant (cumulative effect) and the ability for this energy to be regenerated as quickly as possible. The task of the LCA is to demonstrate that a certain technology and project produce more energy than they consume, as otherwise, there would be no beneficial contribution to the energy

Što je period vraćanja uložene energije brži, rezultati LCA su bolji. U ovakvim razmatranjima nezaobilazan segment bi takođe bila i komparativna analiza s konvencionalnim sistemima za proizvodnju energije, zasnovanim na korišćenju fosilnih goriva, iz čega bi se izveli zaključci o prednostima ili nedostacima korišćenja energije sunca. Pored toga, izuzetno je važno i sagledavanje uticaja na životnu sredinu u procesu dobijanja proizvoda u korelaciji s dobrobitima proizvoda na životnu sredinu.

Pored sveobuhvatnog pristupa koji je karakterističan za LCA, postoje dijametralno suprotni pristupi koji se zasnivaju na proceni uticaja pojedinačnih elemenata životne sredine (vode, vazduha, zemljišta, buke, predela itd.), odnosno na tzv. parcijalnoj proceni (Josimović et al, 2021; Josimović et al, 2021a; Josimović et al, 2023b). U kontekstu procene uticaja solarnih elektrana na životnu sredinu moglo bi se govoriti o parcijalnoj proceni uticaja solarnih elektrana na npr. biodiverzitet ili predeo. Autor, međutim, smatra da je parcijalna procena za pojedinačne elemente životne sredine opravdana samo ukoliko je ona sastavni deo jedinstvene procene uticaja u okviru koje se primenjuje holistički (celovit) pristup proceni uticaja solarnih elektrana na životnu sredinu.

Najzad dolazimo do instrumenata za zaštitu životne sredine koji na globalnom nivou imaju najrasprostranjeniju primenu u proceni uticaja na životnu sredinu, ne samo za solarne elektrane, već za sve druge razvojne planove, strategije, programe, politike i projekte. To su:

- Strateška procena uticaja planova i programa na životnu sredinu – SPU (engl. *Stategic Environmental Assessment – SEA*); i

system. The faster the period of energy payback, the better the LCA results. In such considerations, a comparative analysis with conventional energy production systems based on fossil fuels would also be an essential segment, from which conclusions could be drawn about the advantages or disadvantages of using solar energy. Additionally, it is extremely important to consider the environmental impacts in the process of product acquisition in correlation with the benefits of the product to the environment.

In addition to the comprehensive approach characteristic of LCA, there are diametrically opposite approaches that are based on assessing the impacts of individual environmental elements (water, air, soil, noise, landscape, etc.), known as partial assessments (Josimović et al, 2021; Josimović et al, 2021a; Josimović et al, 2023b). In the context of assessing the impacts of solar power plants on the environment, one could speak of a partial assessment of the impacts of solar power plants on, for example, biodiversity or landscape. However, the author believes that a partial assessment for individual environmental elements is justified only if it is part of a unified impact assessment in which a holistic (comprehensive) approach to assessing the impacts of solar power plants on the environment is applied.

Finally, we come to the environmental protection instruments that have the widest application globally in assessing the impact on the environment, not only for solar power plants but for all other development plans, strategies, programs, policies, and projects. These are:

- Strategic Environmental Assessment of plans and programs - SEA (Strategic Environmental Assessment); and

- Studija o proceni uticaja projekata na životnu sredinu – PU (engl. *Environmental Impact Assessment – EIA* i dopunjena *Environmental and Social Impact Assessment – ESIA*).

Karakteristika oba instrumenta jeste primena holističkog pristupa u sagledavanju interakcija postojećih i planiranih aktivnosti na određenom prostoru. Bitna razlika u pristupu proceni uticaja na životnu sredinu uslovljena je vrstom dokumenata za koje se rade, odnosno fazi razvoja projekta u kojoj se primenjuju. S tim u vezi, strateška procena uticaja primenjuje se na strateškom nivou planiranja, dok se studija o proceni uticaja primenjuje na nivou konkretnih investicionih projekata, odnosno na nivou tehničke dokumentacije.

Upravo je SPU ključni instrument u primeni principa preventivne zaštite, o čemu je već bilo reči u ovoj knjizi, jer se primenjuje u najranijoj fazi razvoja projekta, odnosno tokom planiranja prostornog razvoja. SPU služi za procenu prostornih/teritorijalnih uticaja na životnu sredinu. Imajući u vidu ovu činjenicu, kao i temu i naslov ove knjige, jasno je da SPU zaslužuje posebno mesto (poglavlje) u ovoj knjizi, dok će za procenu uticaja u ovom delu biti dat samo kraći osvrt.

Istorijat primene ovog instrumenta vezuje se za kraj šezdesetih godina prošlog veka, kad je u SAD usvojen zakon koji se odnosio na politiku zaštite životne sredine. Od tog perioda kontinuirano raste interes za razvoj instrumenata za procenu uticaja na životnu sredinu. Ovaj instrument pomaže u rešavanju ekoloških, socijalnih i ekonomskih problema koji mogu nastati realizacijom javnih i privatnih investicionih projekata na određenom prostoru. SPU je alat za upravljanje životnom sredinom i upotrebljava se na nivou

- Environmental Impact Assessment of projects - EIA (Environmental Impact Assessment), and the extended Environmental and Social Impact Assessment - ESIA).

Both instruments are characterized by the application of a holistic approach to examining the interactions of existing and planned activities in a specific area. A significant difference in the approach to assessing environmental impact is determined by the type of documents they are created for, or the phase of project development in which they are applied. In this regard, the Strategic Environmental Assessment (SEA) is applied at the strategic level of planning, while the Environmental Impact Assessment (EIA) is used at the level of specific investment projects, i.e., at the level of technical documentation.

Indeed, SEA is a key instrument in applying the principles of preventive protection, which has already been discussed in this book, as it is applied in the earliest phase of project development, during spatial planning. SEA serves to assess the spatial/territorial impacts on the environment. Considering this fact, as well as the theme and title of this book, it is clear that SEA deserves a special place (chapter) in this book, while the discussion on the EIA in this section will only be brief.

The history of the application of this instrument dates back to the late 1960s when a law related to environmental protection policy was adopted in the USA. Since that time, there has been a continuous growth in interest for the development of instruments for assessing environmental impact. This instrument helps address ecological, social, and economic problems that may arise from the realization of public and private investment konkretnih projekata. Sadrži sistematičnu, dokumentovanu, periodičnu i objektivnu procenu koliko dobro kontrola zagađenja i sistemi upravljanja životnom sredinom mogu da se postignu u funkcionisanju određenog sistema (Muralikrishna and Manickam, 2017).

U evropsku praksu PU je uvedena 1985. godine donošenjem Direktive EU o proceni uticaja na životnu sredinu (engl. EIA Directive (85/337/EEC). Danas je jedan od najrasprostranjenijih instrumenata za procenu uticaja na životnu sredinu. Njena primena je globalna s obzirom na to da se primenjuje u celom svetu.

Danas je u upotrebi veliki broj različitih metodoloških pristupa i metoda koje se primenjuju u PU (MCA – Multi-criteria Analysis; MCDM – Multi-criteria Decision-Making; LM – Leopold Matrix, itd.) a ovom temom bavio se, i i dalje se bavi, veliki broj autora (Jay et al, 2007; Josimović, 2008; Josimović et al, 2014; Podimata, 2016; Kalnins et al, 2016; i dr.). Navedene metode baziraju se na primeni simulacionih matematičkih odnosno softverskih modela, koji rezultiraju objektivnim kvantitativnim iskazima o očekivanim uticajima projekta na životnu sredinu. Ovakav princip uslovljen je dovoljno detaljnim ulaznim podacima o vrstama i količinama materijala, energije i produkata i njihovom kretanju u procesu izgradnje i eksploatacije projekta, koji se koriste za procenu uticaja na životnu sredinu.

Od svog uvođenja, proces PU ima svoj evolutivni put u cilju njenog unapređenja i prilagođavanja aktuelnim trendovima i politikama u oblasti zaštite životne sredine na globalnom i nacionalnom nivou. Jedan od primera je davanje sve većeg značaja sagledavanju socijalnih (društvenih)

projects in a specific area. It is a tool for environmental management and is used at the level of specific projects. It contains a systematic, documented, periodic, and objective evaluation of how well pollution control and environmental management systems can be achieved in the operation of a particular system (Muralikrishna and Manickam, 2017).

The Environmental Impact Assessment (EIA) was introduced into European practice in 1985 with the adoption of the EU EIA Directive (85/337/EEC). Today, it is one of the most widespread tools for assessing environmental impacts. Its application is global as it is used worldwide.

Today, a large number of different methodological approaches and methods are used in EIAs (MCA - Multi-criteria Analysis; MCDM - Multi-criteria Decision-Making; LM – Leopold Matrix, etc.), and this topic has been and continues to be addressed by many authors (Jay et al, 2007; Josimović, 2008; Josimović et al, 2014; Podimata, 2016; Kalnins et al, 2016; and others). These methods are based on the use of simulation mathematical and/or software models, which produce objective quantitative statements about the expected impacts of a project on the environment. This principle is conditioned by sufficiently detailed input data about: types and quantities of materials, energy, and products and their movement in the construction and operation processes of the project, which are used for assessing environmental impacts.

Since its introduction, the EIA process has evolved with the aim of enhancing and adapting it to current trends and policies in environmental protection at both global and national levels. One example is the increasing emphasis on examining social uticaja na lokalnu zajednicu, zbog čega je u poslednje vreme sve više u upotrebi procena uticaja na životnu sredinu i socijalni razvoj (engl. *Environmental and Social Impact Assessment – ESIA*). ESIA se od početka sve više primenjuje na projekte koje finansiraju međunarodne finansijske institucije, poput Svetske banke, EBRD-a i IFC-a, zbog toga što se u okviru nje integralno i transparentno sagledavaju sve posledice realizacije projekta i na taj način procenjuje stepen rizika za njegovu realizaciju. Zato u poslednje dve decenije trendovi idu ka transformaciji PU u ESIA, odnosno ka integrisanoj proceni uticaja na životnu sredinu i socijalni razvoj, kako bi se pravilno shvatilo međusobno povezivanje prirode i društva s realizacijom investicionih projekata (Smart et al, 2014).

Za PU je karakteristično da se ona radi na osnovu egzaktnih i detaljnih podataka o lokaciji i projektu koji je ušao u fazu koja prethodi realizaciji (izgradnji). Upravo ovaj nivo detaljnosti i preciznosti izdvaja PU od drugih instrumenata za procenu uticaja na životnu sredinu. S jedne strane holistički pristup, a s druge kvantitativno iskazivanje rezultata zasnovanih na egzaktnim podacima (inputima), ukazuju i na razloge zbog čega se PU na globalnom nivou, a ne samo u slučaju projekata solarnih elektrana, pozicionirala kao nezaobilazni instrument. Kao što je prethodno navedeno, moguće je primeniti različite metodološke pristupe i metode za procenu uticaja solarnih elektrana na životnu sredinu u okviru PU. O tome postoji više radova u naučnoj literaturi (Josimović et al, 2014; Josimović et al, 2021a; i dr.).

Pri tome uvek treba razmotriti primenu kombinacije više metodoloških pristupa

impacts on local communities, which has led to the more frequent use of Environmental and Social Impact Assessments (ESIA). ESIA has been increasingly applied since its inception, especially in projects financed by international financial institutions such as the World Bank, EBRD, and IFC, because it integrally and transparently examines all consequences of project realization, thus assessing the level of risk for its implementation. Therefore, in the last two decades, trends have been moving towards transforming EIA into ESIA, i.e., towards an integrated assessment of impacts on the environment and social development, in order to properly understand the interconnection of nature and society with the realization of investment projects (Smart et al, 2014).).

EIA (Environmental Impact Assessment) is characterized by being based on precise and detailed data about the location and the project that has entered the pre-implementation (construction) phase. This level of detail and accuracy distinguishes EIA from other environmental impact assessment instruments. On one hand, the holistic approach, and on the other, the quantitative expression of results based on precise data (inputs), illustrate why EIA has positioned itself as an indispensable instrument globally, not just in the case of solar power projects. As previously mentioned, various methodological approaches and methods can be applied to assess the impact of solar power plants on the environment within the EIA framework. This is supported by several works in the scientific literature (Josimović et al, 2014; Josimović et al, 2021a; and others).

In doing so, one should always consider using a combination of multiple methodological approaches and methods, i metoda ili nadograđivati već postojeće metodološke pristupe i metode kako bi se na osnovu konkretnog slučaja dobili najbolji rezultati u PU (Crnčević et al, 2011).

U dosadašnjem istraživačkom opusu autor ove knjige već se bavio analizom mogućnosti nadogradnje postojećih metoda u proceni uticaja na životnu sredinu. Konkretno, na primeru PU za solarne elektrane u Srbiji, autor je prikazao mogućnost nadogradnje metoda Leopoldove matrice. U radu koji je ranije publikovan (Josimović et al, 2014), autor je sa svojim saradnicima prezentovao rezultate ovog istraživanja, koji potvrđuju prednosti ovakvog pristupa u proceni uticaja solarnih elektrana na životnu sredinu. Pokazalo se da je osnovna prednost nadogradnje postojećeg modela stvaranje preduslova za sveobuhvatnu procenu uticaja koja je prilagođena konkretnim uslovima. Ovakvim pristupom stiče se utisak da se za svaki pojedinačni projekat koncipira originalna metodologija pomoću koje je moguće dobiti najbolje rezultate.

Svi instrumenti za pocenu uticaja koji su navedeni u ovom poglavlju tehnički su orijentisani, primenjuju se na nivou pojedinačnih projekata i moguće ih je primeniti i za projekte solarnih elektrana. Na ovom delu, međutim, dolazimo do okolnosti koje u ovom trenutku dovode u pitanje izradu PU za solarne elektrane u Srbiji. Naime, Uredba o utvrđivanju Liste projekata za koje je obavezna procena uticaja i Liste projekata za koje se može zahtevati procena uticaja na životnu sredinu („Službeni glasnik RS"', br. 114/08) ne prepoznaje projekte solarnih elektrana, pa se dovodi u pitanje postojanje pravnog osnova za izradu PU. Godina donošenja

or upgrading existing methodological approaches and methods to achieve the best results in EIA based on the specific case (Crnčević et al, 2011).

The author of this book has in his previous research focused precisely on analyzing the possibilities of upgrading existing methods in environmental impact assessment. Specifically, using the example of EIA for wind farms in Serbia, the author demonstrated the possibility of upgrading the Leopold Matrix method. In a previously published work (Josimović et al, 2014), the author and his colleagues presented the results of this research, which confirm the advantages of this approach in assessing the impact of wind farms on the environment. It has been shown that the main advantage of upgrading the existing model is creating the conditions for a comprehensive impact assessment that is adapted to specific conditions. This approach gives the impression that an original methodology is conceived for each individual project, with the help of which it is possible to achieve the best results..

All the impact assessment instruments mentioned in this chapter are technically oriented and applied at the level of individual projects, and they can also be applied to solar power plant projects. However, at this point, we encounter circumstances that currently call into question the creation of EIAs for solar power plants in Serbia. Specifically, the Regulation on determining the List of projects for which an impact assessment is mandatory and the List of projects for which an impact assessment may be requested ("Official Gazette of RS", No. 114/08) does not recognize solar power plant projects, thus questioning the existence of a legal basis for conducting ovog pravnog akta upućuje na neadekvatno prepoznavanje budućih tendencija u razvoju solarne energetike u trenutku kad je pravni akt formulisan. Nelogičan je izostanak PU za solarne elektrane većeg kapaciteta zbog površine zemljišta koje zauzimaju i drugih uzročno-posledičnih veza u odnosu na životnu sredinu, pa se očekuje promena pravnog akta i dosledna primena savremenih pristupa u realizaciji projekata solarnih elektrana u Srbiji.

Naredno poglavlje posvećeno je predstavljanju jedinog instrumenta za procenu prostornih/teritorijalnih uticaja koja se radi na nivou razvojnih planova i omogućava potpunu primenu principa preventivne zaštite životne sredine.

EIAs. The year this legal act was adopted indicates an inadequate recognition of future trends in solar energy development at the time the act was formulated. It is illogical to omit EIAs for larger-capacity solar power plants due to the land area they occupy and other cause-and-effect relationships with the environment. Therefore, a change in the legal act is expected, along with consistent application of contemporary approaches in the implementation of solar power plant projects in Serbia.

The next chapter is dedicated to presenting the sole instrument for assessing spatial/territorial impacts that is conducted at the level of development plans and allows for the full application of the principles of preventive environmental protection.

4. STRATEŠKA PROCENA UTICAJA KAO INSTRUMENT ZA PROCENU PROSTORNIH UTICAJA RAZVOJNIH PLANOVA NA ŽIVOTNU SREDINU

4.1. O strateškoj proceni uticaja na životnu sredinu

Zakonski regulisana potreba za procenom uticaja planova, strategija, politika i programa na životnu sredinu počela je da se realizuje krajem šezdesetih godina prošlog veka, kad je Nacionalni zakon o životnoj sredini SAD (engl. *National Environmental Policy Act – NEPA*) postavio osnove strateške procene uticaja na životnu sredinu (SPU). Zakon nije pravio razliku između razvojnih dokumenata i investicionih projekata, odnosno između strateškog i projektnog nivoa donošenja odluka, već se uopšteno odnosio na akcije (Fischer, 2002; Dalal-Clayton and Sadler, 2005).

Strateška procena uticaja na životnu sredinu proistekla je iz projektno orijentisane procene uticaja na životnu sredinu (PU) i kao takva formulisana 1989. godine u Velikoj Britaniji. U to vreme nije se prepoznavala suštinska razlika između SPU i PU, ali se s vremenom obim interpretacija SPU počeo proširivati u sistematski i sveobuhvatni proces koji vrednuje uticaje na životnu sredinu planova, politika i programa, razmatra alternative, sadrži pisani izveštaj o vrednovanju na osnovu kog se donose odluke (Therivel and Partidario, 1996).

4. STRATEGIC ENVIRONMENTAL ASSESSMENT AS AN INSTRUMENT FOR ASSESSING THE SPATIAL IMPACTS OF DEVELOPMENT PLANS ON THE ENVIRONMENT

4.1. On the Strategic Environmental Assessment

The legally regulated need for assessing the impact of plans, strategies, policies, and programs on the environment began to be implemented in the late 1960s, when the National Environmental Policy Act (NEPA) in the USA laid the groundwork for Strategic Environmental Assessment (SEA). The law did not distinguish between development documents and investment projects, or between the strategic and project levels of decision-making, but generally referred to actions (Fischer, 2002; Dalal-Clayton and Sadler, 2005).

Strategic Environmental Assessment emerged from project-oriented environmental impact assessment (EIA) and was formulated as such in 1989 in Great Britain. At that time, there was no recognition of a substantive difference between SEA and EIA, but over time, the scope of SEA interpretation began to expand into a systematic and comprehensive process that evaluates the environmental impacts of plans, policies, and programs, considers alternatives, and includes a written evaluation report upon which decisions are made (Therivel and Partidario, 1996).

Jedna od univerzalnih i opšteprihvaćenih definicija SPU jeste ona po kojoj je SPU „deo sistematskog procesa za vrednovanje posledica na životnu sredinu predložene politike, plana ili programa kako bi one bile u potpunosti uključene i na odgovarajući način obrađene u najranijem mogućem stupnju donošenja odluka, ravnopravno sa ekonomskim i socijalnim razmatranjima" (Partidario, 1996). Internacionalna i praktična iskustva Svetske banke upućuju na to da SPU predstavlja „participativni pristup za povećanje uticaja socijalnih pitanja i pitanja životne sredine na procese razvojnog planiranja i odlučivanja na strateškom nivou" (Mercier and Ahmed, 2004; Dalal-Clayton and Sadler, 2005).

SPU danas predstavlja jedan od najznačajnijih instrumenata za donošenje odluka o prihvatljivosti predložene politike na životnu sredinu, odnosno za implementaciju strategije održivog razvoja u kreiranju politike postornog razvoja u oblastima strateškog planiranja, prostornog i urbanističkog planiranja, planiranja sektorskih politika itd. Glavna namena SPU jeste da olakša blagovremeno i sistematično razmatranje mogućih uticaja na životnu sredinu na osnovu kojih se donose odluke o razvojnim politikama na strateškom nivou i njihovoj prihvatljivosti sa aspekta održivosti (Josimović et al, 2015, Josimović 2017).

O ulozi i značaju SPU u kreiranju politika u različitim strateškim dokumentima koja se bave prostornim razvojem pisao je od sredine devedesetih godina 20. veka do danas veliki broj autora (Nilsson and Dalkmann, 2001; Nilsson et al, 2005; Maričić i Josimović 2005; Josimović i Crnčević, 2009; Josimović and Crnčević, 2010;

One of the universal and widely accepted definitions of SEA is that it is "part of a systematic process for evaluating the environmental consequences of proposed policies, plans, or programs to ensure that they are fully considered and appropriately addressed at the earliest possible stage of decision-making, on par with economic and social considerations" (Partidario, 1996). International and practical experiences of the World Bank suggest that SEA represents a "participatory approach to increasing the influence of social and environmental issues on strategic-level development planning and decision-making" (Mercier and Ahmed, 2004; Dalal-Clayton and Sadler, 2005).

SEA today represents one of the most significant instruments for decision-making on the acceptability of proposed environmental policies, or for implementing sustainable development strategy in creating spatial development policy in areas such as: strategic planning; spatial and urban planning; sectoral policy planning; etc. The main purpose of SEA is to facilitate timely and systematic consideration of potential environmental impacts upon which decisions on development policies at the strategic level and their sustainability are made (Josimović et al., 2015, Josimović 2017).

The role and significance of SEA in policy-making in various strategic documents dealing with spatial development have been written about by a large number of authors from the mid-1990s to the present day (Nilsson and Dalkmann, 2001; Nilsson et al., 2005; Maričić and Josimović 2005; Josimović and Crnčević, 2009; Josimović and Crnčević, 2010; Josimović et al., 2011; White and Noble 2013; Nenković et al., 2014; Josimović et al., 2016, 2016a;

Josimović et al, 2011; White and Noble 2013; Nenković et al, 2014; Josimović et al, 2016, 2016a; Krunić et al, 2017; Krunić et al, 2019; Josimović et al, 2022; i drugi). Autori se uglavnom slažu u vezi sa značajem primene SPU u kreiranju politike i donošenju optimalnih odluka o prostornom razvoju. Ovu konstataciju potvrđuje i činjenica da sve veći broj međunarodnih institucija, poput Evropske komisije, Svetske banke, UNDP, uvodi zahteve za primenu SPU radi povećanja broja razvojnih inicijativa koje su u skladu sa zaštitom životne sredine (Chaker et al, 2006; Dalal-Clayton and Sadler, 2005).

Autorov naučnoistraživački opus i stručni rezultati u primeni SPU bazirani su na evropskom iskustvu. Zbog toga se autor opredelio da u ovom delu knjige prikaže evropsku praksu u primeni SPU, bez namere da na taj način umanji značaj i ulogu SPU u planiranju prostornog razvoja u drugim delovima sveta. Autorova namera nije ni da favorizuje evropsku praksu u primeni SPU u odnosu na iskustva iz drugih delova sveta, niti da vrši komparativnu analizu, već je namera isključivo povezana s teritorijalnom determinacijom u primeni SPU koja je autoru bliska i u kojoj se on oseća komforno. U tom kontekstu potrebno je navesti dva osnovna pravna dokumenta koja daju smernice za primenu SPU u zemljama Evropske unije, i to: Evropsku direktivu o proceni uticaja određenih planova i programa na životnu sredinu i Protokol o strateškoj proceni uticaja na životnu sredinu. Oba dokumenta imaju za osnovni cilj postizanje visokog nivoa kvaliteta zaštite životne sredine i unapređenje održivog razvoja u svim zemljama članicama EU, uz uključivanje svih faktora bitnih za životnu sredinu u procesu pripreme i usvajanja planova i programa.

Krunić et al., 2017; Krunić et al., 2019; Josimović et al., 2022; and others). Generally, authors agree on the importance of SEA application in policy-making and making optimal decisions on spatial development. This observation is also confirmed by the fact that an increasing number of international institutions, such as the European Commission, the World Bank, UNDP, are introducing requirements for SEA application to increase the number of development initiatives that are environmentally compatible (Chaker et al., 2006; Dalal-Clayton and Sadler, 2005).

The author's scientific research and professional results in the application of SEA are based on European experience. Therefore, the author has chosen to present European practice in the application of SEA, without intending to diminish the significance and role of SEA in spatial development planning in other parts of the world. The author's intention is neither to favour European practice in the application of SEA over experiences from other parts of the world, nor to conduct a comparative analysis, but solely to connect with the territorial determination in the application of SEA that is close to the author and in which they feel comfortable. In this context, it is necessary to mention two basic legal documents that provide guidelines for the application of SEA in the European Union countries, namely: the European Directive on the Assessment of the Effects of Certain Plans and Programs on the Environment; and the Protocol on Strategic Environmental Assessment. Both documents have the primary goal of achieving a high level of environmental protection and promoting sustainable development in all EU member states, by including all factors relevant to the environment in the process of preparing and adopting plans and programs.

Evropska direktiva o SPU (engl. *European Strategic Environmental Assessment Directive* 2001/42/ EC) odnosi se na planove i programe koje priprema odnosno usvaja organ na nacionalnom, regionalnom ili lokalnom nivou, koji se donose na osnovu propisa iz oblasti poljoprivrede, šumarstva, ribarstva, energetike, industrije, saobraćaja, upravljanja otpadom, upravljanja vodama, turizma, urbanizma, kojima se uspostavlja okvir za davanje dozvola za projekte budućeg razvoja i koji obuhvataju projekte koji podležu proceni uticaja projekta na životnu sredinu.

SPU protokol (engl. *Protocol on Strategic Environmental Assessment*) je pravno obavezujući, dodatak Konvenciji o proceni uticaja na životnu sredinu u prekograničnom kontekstu (ESPOO konvencija). Zahteva od svih zemalja koje su ga ratifikovale da vrednuju nacrte planova i programa sa aspekta mogućih implikacija na životnu sredinu. Protokol insistira na potrebi jasnog i transparentnog uključivanja javnosti koja se aktivira već u procesu odlučivanja o obuhvatu SPU.

Postoje dva pristupa SPU. Prvi tretira SPU kao proces koji je usmeren na pitanja zaštite životne sredine, dok drugi pristup pretpostavlja SPU kao instrument u funkciji sagledavanja održivosti, u kom se paralelno sa zaštitom životne sredine obrađuju ekonomska i socijalna pitanja. Autor ove knjige smatra da ni jedan od dva navedena pristupa nije formulisan na objektivnim osnovama jer pojam „životna sredina” pored prirodne sredine obuhvata i čoveka u njoj i sve njegove aktivnosti. Evidentno je da je u SPU potrebno sagledavati simbiozu svih pojava i procesa na određenom prostoru. To znači da socijalne

The European Directive on SEA (European Strategic Environmental Assessment Directive 2001/42/EC) applies to plans and programs: prepared and/or adopted by a national, regional, or local authority; which are adopted based on regulations; in the fields of agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, tourism, urban planning, which establish a framework for granting permits for future development projects; which encompass projects subject to environmental impact assessment.

The SEA Protocol (Protocol on Strategic Environmental Assessment) is a legally binding addition to the Convention on Environmental Impact Assessment in a Transboundary Context (the ESPOO Convention). It requires all countries that have ratified it to evaluate draft plans and programs in terms of potential environmental implications. The Protocol insists on the need for clear and transparent public involvement, which is activated as early as the process of determining the scope of SEA decision-making.

There are two approaches to SEA. The first treats SEA as a process focused on environmental protection issues, while the second approach assumes SEA as an instrument for assessing sustainability in which environmental protection, economic, and social issues are simultaneously addressed. The author of this book believes that neither of the two approaches is formulated on objective grounds because the concept of “environment” encompasses not only the natural environment but also humans and all their activities within it, it is evident that in SEA, the symbiosis of all phenomena and processes in a particular area needs to be considered. This means i ekonomske aspekte nikako ne možemo odvojiti/izdvojiti iz životne sredine već ih treba sagledavati holistički. Svaki drugi pristup, čijom primenom bi se selektivno i parcijalno sagledavao određeni prostor, ne bi bio ispravan.

Suština primene SPU leži u usmeravanju procesa planiranja ka definisanim cilje vima održivog razvoja, s jedne strane, i procena i identifikacija strateški značajnih teritorijalnih uticaja određene politike koji služe za donošenje odluke o prostornom razvoju, s druge strane. Primenom SPU u planiranju prostornog razvoja kroz različita razvojna dokumenta moguće je sagledati posledice predloženih razvojnih koncepcija i promena u prostoru, uz uvažavanje kapaciteta prostora i mogućnosti da se izbegne preopterećenje tog istog prostora, uz nezaobilazno uključivanje javnosti u sve faze izrade i usvajanja SPU. U tom kontekstu, evidentno je da se na osnovu svih informacija koje se dobiju u kompleksnoj proceduri sprovođenja SPU daje značajan doprinos procesu donošenja odluka o budućem razvoju nekog prostora (Salhofer et al, 2007).

that social and economic aspects cannot be separated from the environment but must be viewed holistically. Any other approach, which would selectively and partially consider a specific area, would be incorrect.

The essence of SEA application is to direct planning processes toward defined sustainable development goals, on one hand, and to assess and identify strategically significant territorial impacts of certain policies that serve as a basis for spatial development decisions, on the other hand. By applying SEA in spatial development planning through various development documents, it is possible to assess the consequences of proposed development concepts and changes in space, considering the capacity of the area and the possibility to avoid overloading that same area, with the inevitable involvement of the public in all stages of SEA preparation and adoption. In this context, it is evident that based on all the information obtained in the complex process of implementing SEA, a significant contribution is made to the decision-making process on the future development of an area (Salhofer et al., 2007).

4.2. Metodologija strateške procene uticaja na životnu sredinu

Koncept metodologije SPU, za razliku od raznovrsnih, preciznih i visokooperativnih softverskih alata koji se koriste u inženjerskoj okolini (kada se uobičajeno primenjuju projektno orijentisane procene uticaja na životnu sredinu) prilično je nejasan (Liou et al, 2005). Neki autori (Brown and Therivel, 2000; Partidario, 2000) tvrde da ne postoji generalizovana metodologija SPU koja se primenjuje na sve planove i razvojne politike i da

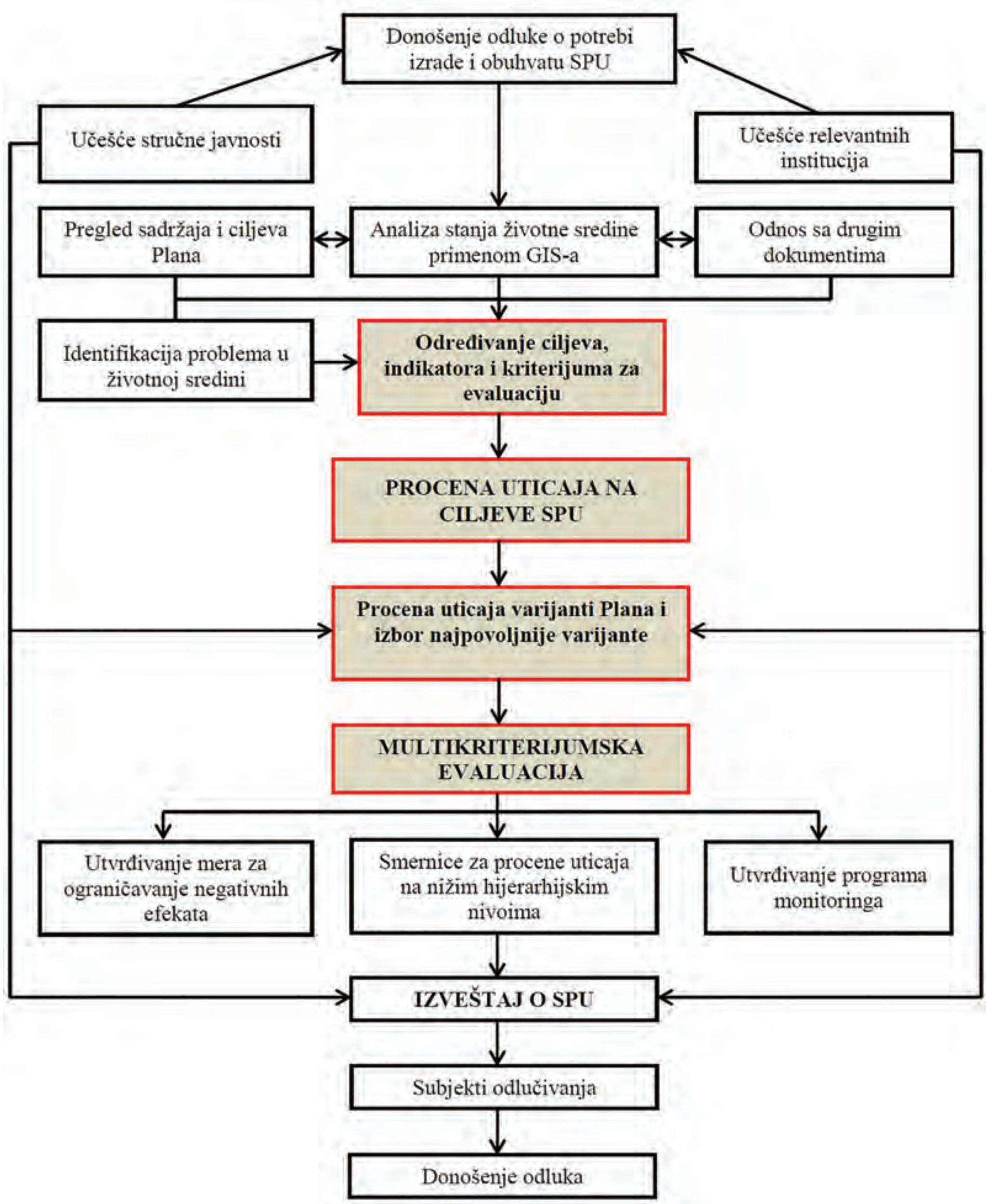
4.2. Methodology of Strategic Environmental Assessment

The methodology concept of Strategic Environmental Assessment (SEA), unlike various precise and highly operational software tools used in an engineering environment (where project-oriented environmental impact assessments are commonly applied), is rather unclear (Liou et al, 2005). Some authors (Brown and Therivel, 2000; Partidario, 2000) argue that there is no generalized SEA methodology applicable to all plans and development metodologiju SPU treba tretirati kao skup alata u jednom paketu alata, iz kog svaki korisnik može izabrati svoje alate u zavisnosti od posebnih potreba. Zato se SPU može smatrati interdisciplinarnom međusektorskom oblašću, u kojoj se naglašavaju integracija i timski rad i u kome se primenjuju različiti metodološki pristupi, o čemu je već diskutovano u literaturi (Sheate et al, 2001). Osim toga, Marsden (2002) je istakao da se SPU uglavnom oslanja na kvalitativno razmatranje, zbog čega ekspertska procena igra ključnu ulogu. Pitanje izbora odgovarajuće metodologije procene koja se koristi u konkretnom slučaju mora biti u korelaciji sa odgovarajućim iskustvima implementacije akumulirana kroz komparativne studije ranije primenjivanih metodologija koje su pokazale dobre rezultate u primeni SPU (Liou et al, 2005; Josimović and Crnčević, 2009; Josimović et al, 2015).

U praksi SPU najčešće se koriste kvalitativne ekspertske metode kao što su matrice, višekriterijumske analize, SWOT analize, Delfi metoda, procene rizika, itd. Kao rezultat primene bilo koje metode pojavljuju se obično matrice. Matrice se formiraju uspostavljanjem odnosa između ciljeva politike prostornog razvoja, planskih rešenja i ciljeva strateške procene kojima su određeni pripadajući/odgovarajući indikatori.

policies, and that SEA methodology should be treated as a toolkit from which each user can choose their tools depending on specific needs. Therefore, SEA can be considered an interdisciplinary, intersectoral area where integration and teamwork are emphasized, applying various methodological approaches, as has already been discussed in the literature (Sheate et al, 2001). Additionally, Marsden (2002) pointed out that SEA primarily relies on qualitative consideration, which makes expert assessment play a crucial role. The choice of an appropriate assessment methodology used in a specific case must correlate with the relevant implementation experiences accumulated through comparative studies of previously applied methodologies that have shown good results in SEA application (Liou et al, 2005; Josimović and Crnčević, 2009; Josimović et al, 2015).

In SEA practice, qualitative expert methods such as matrices, multi-criteria analyses, SWOT analyses, Delphi method, risk assessments, etc., are most commonly used. As a result of applying any method, matrices usually emerge. Matrices are formed by establishing relationships between the goals of spatial development policy, planning solutions, and the goals of strategic assessment to which corresponding/appropriate indicators are assigned.



Slika 20. Proceduralni i metodološki okvir primene SPU (izvor: autor, original)

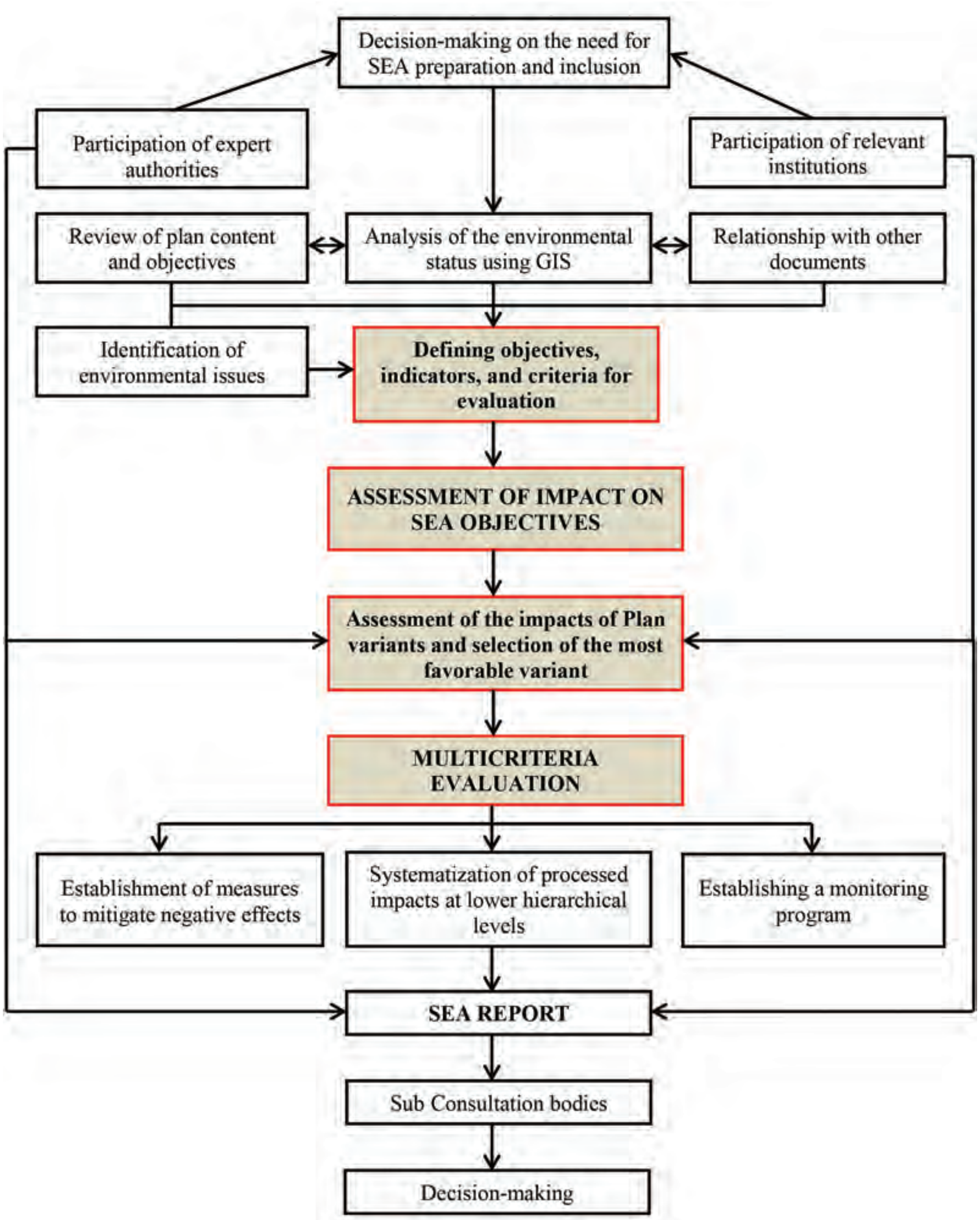


Figure 20. Procedural and Methodological Framework for SEA Implementation (Source: author, original)

Na slici 20 prikazan je proceduralni i metodološki okvir primene SPU zasnovan na propozicijama Evropske direktive o SPU s kojom su usklađene nacionalne legislative evropskih zemalja. Ono što zaokuplja posebnu pažnju istraživača, a što nije definisano ni u Direktivi o SPU, niti ga je moguće definisati u nacionalnim legislativama, međutim, jeste sam metod koji se koristi u proceni uticaja u okviru SPU (uokvireno crvenom bojom na slici 20).

Primena ekspertskih kvalitativnih metoda pruža velike mogućnosti da se metodološki pristup u proceni uticaja na nivou SPU prilagodi konkretnim okolnostima, kao i da se primeni kombinacija različitih metodoloških pristupa i metoda za procenu uticaja kako bi se dobili najbolji rezultati, koji u konkretnom slučaju treba da predstavljaju osnov za donošenje odgovarajućih odluka o prostornom razvoju. S obzirom na to da je osnovna karakteristika kvalitativnih ekspertskih metoda subjektivnost, potrebno je pimenjivati tehnike i alate kojima će se postići najveća moguća objektivnost u proceni uticaja. U tom kontekstu, autor ove knjige posebno ističe ulogu i značaj primene GIS tehnologije u ovom postupku (Josimović i Krunić, 2008), o čemu pišu i drugi autori (Campo, 2017; García-Ayllón, 2017; Pedro et al, 2017).

Figure 20 illustrates the procedural and methodological framework for SEA implementation based on the propositions of the European SEA Directive, which are aligned with the national legislations of European countries. However, what particularly interests researchers, and what is not defined in either the SEA Directive or national legislations, is the method used in impact assessment within SEA (highlighted in red in Figure 30).

The application of expert qualitative methods offers significant possibilities to methodologically adapt the impact assessment approach at the SEA level to specific circumstances and to apply a combination of different methodological approaches and methods for impact assessment in order to obtain the best results. These results, in a specific case, should serve as a basis for making appropriate decisions on spatial development. Given that the fundamental characteristic of qualitative expert methods is subjectivity, it is necessary to apply techniques and tools that will achieve the highest possible objectivity in impact assessment. In this context, the author of this book particularly emphasizes the role and significance of applying GIS technology in this process (Josimović and Krunić, 2008), which is also discussed by other authors (Campo, 2017; García-Ayllón, 2017; Pedro et al, 2017).

4.2.1. Primena metode višekriterijumske evaluacije u proceni uticaja

Jedan od najčešće korišćenih metoda za procenu uticaja u okviru SPU jeste metod višekriterijumske evaluacije (engl. *Multi-Criteria Evaluation* – MCE) planskih koncepcija. Metod MCE je razvijen početkom sedamdesetih godina prošlog veka i danas se smatra dobro razvijenim naučnim poljem podržanim velikim brojem naučnih referenci (Kangas and Kangas, 2005; Ananda and Heralth, 2009; Josimović and Petrić, 2006; i dr.). Inicijalno je karakterisao princip odlučivanja na bazi više kriterijuma sa skromnom participacijom javnosti ili bez nje (Zionts, 1979; Zionts and Vallenius, 1976). Primarni cilj je bio da se kao rezultat dobiju jasne informacije za donošenje odluka, a potom reši dobro strukturiran problem pomoću matematičkih algoritama. Ideje proceduralne racionalnosti i konstruktivnog ili kreativnog pristupa dovele su do razvoja metoda MCE do nivoa da je čitav koncept primene usmeren na proces donošenja optimalnih odluka, što podrazumeva neizostavno uključivanje javnosti u proces MCE (Noorollahi et al, 2016). U tom kontekstu, odgovarajuće razmatranje je preduslov za osiguranje ishoda kvaliteta procesa.

Metod MCE danas se često preporučuje kao pogodna podrška u procesu donošenja odluka zbog svog kapaciteta da na više načina ukazuje na višestruke alternative razvoja na osnovu procene kriterijuma u vezi sa životnom sredinom i socioekonomskim aspektima održivog razvoja (Josimović et al, 2015).

4.2.1. Application of Multi-Criteria Evaluation Method in Impact Assessment

One of the most frequently used methods for impact assessment within SEA is the Multi-Criteria Evaluation (MCE) method for planning concepts. The MCE method was developed in the early 1970s and today is considered a well-developed scientific field supported by a large number of scientific references (Kangas and Kangas, 2005; Ananda and Herath, 2009; Josimović and Petrić, 2006; et al.). Initially, it was characterized by a multi-criteria-based decision-making principle with modest or no public participation (Zionts, 1979; Zionts and Wallenius, 1976). The primary goal was to obtain clear information for decision-making and then to resolve a well-structured problem using mathematical algorithms. The ideas of procedural rationality and a constructive or creative approach led to the development of MCE methods to the level where the entire concept of application is focused on the process of making optimal decisions, which implies the indispensable inclusion of the public in the MCE process (Noorollahi et al, 2016). In this context, appropriate consideration is a prerequisite for ensuring quality process outcomes.

The MCE method is often recommended today as suitable support in the decision-making process due to its capacity to indicate multiple development alternatives based on the assessment of criteria related to the environment and socio-economic aspects of sustainable development in various ways. (Josimović et al, 2015).

4.3. Mogućnost primene SPU u planiranju solarnih elektrana

Iako je naučna literatura koja se bavi ovom temom oskudna, činjenica je da se primena SPU u planiranju solarnih elektrana, kao svaka druga SPU bazira na primeni principa preventivne zaštite i smernicama za izbor optimalnih opcija za minimiziranje ili potpuno sprečavanje potencijalnih konflikata u prostoru koji mogu nastati u korelaciji solarnih elektrana sa elementima životne sredine (prirodnim i antropogenim). Optimalne opcije traže se u analizi prostornih odnosa solarnih elektrana u odnosu na zauzimanje zemljišta, biodiverzitet, predeo i socio-ekonomske aspekte razvoja.

U metodološkom smislu, pristup u planiranju solarnih elektrana i primeni SPU u tom procesu ne razlikuje se od uobičajenog pristupa koji se primenjuje u planskom procesu. U tom kontekstu, u SPU procesu za solarne elektrane takođe je moguće primeniti različite kvalitativne ekspertske metode (Saraji et al, 2024; Zárate-Toledo, 2021) u kombinaciji s kvantitativnim metodama koje se primenjuju za parcijalne procene uticaja (opisano u tački 3.3). Drugim rečima, specifičnosti planiranja projekata solarnih elektrana uslovljavaju odabir kombinacije metodološkog pristupa, odnosno kombinaciju metoda i tehnika koje se često formulišu u formi semikvantitativnog metoda višekriterijumske evaluacije o kojoj je autor ove knjige dosta pisao u većini svojih radova koji se nalaze na spisku literature na kraju knjige.

4.3. Possibility of SEA Application in Solar Power Plant Planning

Although there is limited scientific literature on this topic, the fact remains that the application of SEA in solar power plant planning, like any other SEA, is based on the principles of preventive protection and guidelines for selecting optimal options to minimize or prevent potential conflicts in the spatial domain that may arise in correlation with solar power plants and environmental elements (natural and anthropogenic). Optimal options are sought in the analysis of the spatial relationships of solar power plants concerning land use, biodiversity, landscape, and socio-economic aspects of development.

In a methodological sense, the approach to planning solar power plants and the application of SEA in that process does not differ from the usual approach applied in the planning process. In this context, in the SEA process for solar power plants, it is also possible to apply various qualitative expert methods (Saraji et al., 2024; Zárate-Toledo, 2021) in combination with quantitative methods used for partial impact assessments (described in section 3.3.). In other words, the specificities of planning solar power plant projects condition the choice of a combination of methodological approaches, that is, a combination of methods and techniques that are often formulated into the form of a semi-quantitative multi-criteria evaluation method, which the author of this book has written about extensively in most of his works listed in the literature at the end of the book.

Pored toga, sama specifičnost planerskog pristupa u realizaciji solarnih elektrana utiče na pristup izradi SPU (ili izostavljanje ovog procesa). Specifičnosti u planiranju solarnih elektrana jesu:

- planski dokument za koji se sprovodi postupak SPU atipično obuhvata samo jedan projekat (jednu solarnu elektranu);
- već u toku izrade planskog dokumenta poznati su mnogi tehnički detalji, nekada i tip opreme i solarnih panela koji će se postavljati;
- iako se često planira samo jedna solarna elektrana, potreban je znatan prostor za realizaciju solarne elektrane, što iziskuje značajne prostorne analize, a često i kontinuirane ciljane opservacije na terenu.

Sve navedene činjenice mogu upućivati na pitanje o mogućnosti direktne primene PU, odnosno na izostavljanje („preskakanje") sprovođenja procedure SPU jer postoje elementi za tako nešto (jedan projekat – jedna lokacija – poznati tehnički detalji projekta). Ovo inicijalno može biti primamljiva opcija za investitore koji često sagledavaju vreme kroz novac, pogotovo za one investitore koji ne poznaju važnost dokumenata u oblasti zaštite životne sredine prilikom odobravanja kredita za realizaciju projekta od strane međunarodnih finansijskih institucija. Upravo te institucije, međutim, preferiraju princip preventivne zaštite kao najdelotvorniji pristup u efikasnoj zaštiti živtne sredine, a takav pristup se može ostvariti isključivo kros proces SPU.

Furthermore, the specific approach to planning solar power plants affects the approach to preparing SEA (or omitting this process). The specificities in planning solar power plants are:

- The planning document for which SEA is conducted atypically encompasses only one project (one solar power plant);
- Many technical details, sometimes even the type of equipment and solar panels to be installed, are known during the preparation of the planning document;
- Although only one solar power plant is often planned, the required space for its implementation is significant, requiring extensive spatial analysis and often continuous targeted field observations.

All these facts may raise the question of the possibility of directly applying SEA, or skipping the SEA procedure, as there are elements for such an action (one project - one location - known technical project details). Initially, this may seem like an attractive option for investors who often view time as money, especially for those investors who are unaware of the importance of environmental protection documents when approving project financing by international financial institutions. However, precisely these institutions prefer the principle of preventive protection as the most effective approach to environmental protection, and such an approach can only be achieved through the SEA process.

U kontekstu navedenih konstatacija, može se, dakle, zaključiti da postoje dva ključna argumenta za sprovođenje postupka SPU kad je u pitanju planiranje solarnih elektrana:

1. primena koncepta preventivne zaštite moguća je samo ukoliko se na nivou planiranja solarnih elektrana utiče na prostornu mikrolokacijsku determinaciju solarnih panela unutar solarne elektrana i time utiče na optimalan izbor lokacije kojom se prevenira uticaj na biodiverzitet, predeo i zauzimanje kvalitetnog zemljišta; i
2. međunarodne finansijske institucije koje investitorima obezbeđuju sredstva za realizaciju projekata solarnih elektrana posebnu pažnju posvećuju upravo aspektu uticaja projekta na životnu sredinu u okviru tzv. procene finansijskog rizika, pa je primena principa preventivne zaštite u okviru postupka SPU jedini ispravan pristup. Primenom SPU u planiranju solarnih elektrana može se postići da se mogući uticaji projekta na životnu sredinu kreditorima učine prihvatljivim (ekonomski argument je često presudan za izbor odgovarajućeg pristupa u realizaciji projekta).

Prihvatajući argumente koji upućuju na to da je SPU nezaobilazan instrument u planiranju solarnih elektrana, nadalje se može analizirati koje okolnosti su moguće u planiranju solarnih elektrana i primeni SPU u tom procesu.

In the context of the aforementioned observations, it can be concluded that there are two key arguments for conducting the SEA process when it comes to planning solar power plants:

1. The application of the concept of preventive protection is only possible if spatial micro-location determination of solar panels within solar power plants is influenced at the planning level, thus affecting the optimal choice of location to prevent impacts on biodiversity, landscape, and the occupation of quality land; and
2. International financial institutions that provide funding to investors for solar power plant projects pay special attention to the environmental impact aspect within the so-called financial risk assessment, making the application of the principle of preventive protection within the SEA process the only correct approach. By applying SEA in solar power plant planning, it is possible to make the potential impacts of the project on the environment acceptable to creditors (economic arguments are often crucial in choosing the appropriate approach to project implementation).

Accepting arguments that indicate that SEA is an indispensable tool in solar power plant planning, it is possible to further analyse the circumstances possible in solar power plant planning and the application of SEA in this process.

U nastavku su prikazane opcije za stvaranje planskog osnova za realizaciju projekata solarnih elektrana i izradu SPU.

Najpovoljnija okolnost je *planiranje razvoja sektora solarne energetike na nacionalnom ili regionalnom nivou*. U tom slučaju SPU može da ostvari svoj pun kapacitet na nivou strateškog planiranja na taj način što može da sagleda prostorne mogućnosti velikog ili većeg broja solarnih elektrana na nacionalnom ili regionalnom nivou, sa svim mogućim implikacijama na prostor i životnu sredinu, uključujući korelaciju s drugim antropogenim aktivnostima koje egzistiraju ili se planiraju u prostoru. Rezultati ovako urađene SPU predstavljali bi izuzetan doprinos za određivanje optimalnog broja, veličine i pozicije solarnih elektrana na nacionalnom ili regionalnom nivou kako bi se izbeglo neravnomerno prostorno raspoređivanje solarnih elektrana i moguće društvene reperkusije, poput onih koji su knjizi već elaborirane na osnovu iskustva u Južnoj Koreji. Iako nije redak slučaj u svetu da se strategija razvoja solarne energetike koncipira na nacionalnom nivou, obično se to radi kao deo nacionalnih strategija razvoja energetike ili se sagledavaju samo pojedini prostorni aspekti, bez prostornih analiza za lociranje solarnih elektrana. Imajući u vidu da je izgradnja solarnih elektrana rezultat pojedinačnih inicijativa investitora, a vrlo retko nacionalne vizije s kojom su upoznati kreatori prostornog razvoja na nacionalnom i regionalnom nivou, ne čudi da je okolnost planiranja razvoja sektora solarne energetike na nacionalnom i regionalnom nivou, uz primenu SPU, vrlo retka u praksi i čini se samo kao dobra zamisao.

Options for creating planning foundations for solar power plant projects and preparing SEA are presented below.

The most favourable circumstance is *the planning of solar energy sector development at the national or regional level*. In this case, SEA can realize its full capacity at the strategic planning level by considering the spatial possibilities of a large or larger number of solar power plants at the national or regional level, with all possible implications for space and the environment, including correlation with other anthropogenic activities existing or planned in the space. The results of such an SEA would represent a significant contribution to determining the optimal number, size, and position of solar power plants at the national or regional level to avoid uneven spatial distribution of solar power plants and possible social repercussions, as already elaborated in the book based on experience in South Korea. Although it is not uncommon worldwide for the strategy of solar energy development to be conceived at the national level, it is usually done as part of national energy development strategies or only specific spatial aspects are considered, without spatial analysis for locating solar power plants. Considering that the construction of solar power plants is the result of individual investor initiatives, and very rarely of national visions known to spatial development planners at the national and regional levels, it is not surprising that the circumstance of planning solar energy sector development at the national and regional levels, with SEA application, is very rare in practice and seems only like a good idea.

Okolnost koja je realnija u praksi jeste *planiranje solarnih elektrana na lokalnom nivou,* za potrebe konkretnog projekta, što je slučaj koji postoji u praksi gotovo po pravilu. U ovom slučaju poznate su sve okolnosti za primenu SPU u planiranju (okvirna lokacija, kapaciteti, prostor koji je potreban za solarne panele). U ovim okolnostima, osnovna uloga SPU u procesu planiranja jeste određivanje mikrolokacijske determinacije solarnih panela u odnosu na prostorne odnose, pojave i procese na konkretnoj lokaciji. Iako deluje da je ova druga okolnost limitirajuća za primenu SPU i njen pun doprinos, situacija je zapravo drugačija. Naime, primenom SPU u planiranju na lokalnom nivou moguće je zbog dostupnosti preciznih podataka, obuhvatiti sve oblasti SPU, uključujući i analizu varijantnih rešenja, koja se u ovom slučaju mogu odnositi npr. na zoniranje grupa solarnih panela u okviru jedne solarne elektrane, u cilju stvaranja potrebnih koridora za neometano funkcionisanje drugih infrastrukturnih objekata, kretanje divljih životinja, izbegavanje važnih staništa,limitiranje negativnih uticaja na predeo itd.

A more realistic circumstance in practice is *the planning of solar power plants at the local level* for the needs of a specific project, a case that exists in practice almost invariably. In this case, all circumstances for SEA application in planning are known (approximate location, capacities, space required for solar panels). In these circumstances, the primary role of SEA in the planning process is to determine the micro-location determination of solar panels concerning spatial relationships, phenomena, and processes at the specific location. Although it may seem that this second circumstance is limiting for SEA application and its full contribution, the situation is actually different. Namely, by applying SEA in planning at the local level, due to the availability of precise data, it is possible to encompass all areas of SEA, including the analysis of variant solutions, which in this case may relate, for example, to zoning groups of solar panels within one solar power plant to create necessary corridors for the unhindered functioning of other infrastructure objects, wildlife movement, avoidance of important habitats, limiting negative landscape impacts, etc.

5. PRIMENA SPU U PLANIRANJU SOLARNE ELEKTRANE BREBEKS – STUDIJA SLUČAJA

Dok su prethodna poglavlja bila posvećena pregledu teorijskih razmatranja različitih aspekata solarne energetike, pri čemu je akcenat stavljen na procenu mogućih uticaja solarnih elektrana na životnu sredinu, ovo poglavlje je aplikativnog karaktera. U njemu je na konkretnom primeru prikazana primena SPU u planiranju solarne elektrane u Srbiji[2].

Kao što je ranije navedeno, autor ove knjige ima znatno iskustvo u proceni uticaja velikih solarnih elektrana na životnu sredinu, a jedna od njih je upravo ova koja je uzeta kao studija slučaja. Radi se o projektu solarne elektrane Brebeks (originalnog naziva *Brebex*), čija je realizacija planirana na teritoriji opštine Dimitrovgrad, uz samu granicu s Bugarskom. U ovom delu knjige korišćeni su rezultati Izveštaja o strateškoj proceni uticaja Plana detaljne regulacije solarne elektrane Brebeks na životnu sredinu (2023).

2 SPU se uvodi u praksu planiranja u Republici Srbiji usvajanjem Zakona o zaštiti životne sredine („Službeni glasnik RS", broj 135/2004, 36/09 i 72/09 – 43/11 – Ustavni sud). Prema članu 35. ovog zakona, „Strateška procena uticaja na životnu sredinu vrši se za planove, programe i osnove u oblasti prostornog i urbanističkog planiranja ili korišćenja zemljišta, energetike, industrije, saobraćaja, upravljanja otpadom, upravljanja vodama i drugih oblasti i sastavni je deo plana, odnosno programa ili osnove". Istovremeno sa ovim sistemskim zakonom, usvojen je i poseban Zakon o strateškoj proceni uticaja na životnu sredinu („Službeni glasnik RS", broj 135/2004 i 88/2010).

5. APPLICATION OF SEA IN PLANNING THE "BREBEX" SOLAR POWER PLANT - CASE STUDY

While previous chapters were dedicated to reviewing theoretical considerations of various aspects of solar energy, with a focus on assessing potential impacts of solar power plants on the environment, this chapter is of an applied nature. It demonstrates the application of Strategic Environmental Assessment (SEA) in planning a solar power plant in Serbia using a specific example[2].

As previously mentioned, the author of this book has significant experience in assessing the impacts of large solar power plants on the environment, and one of them is precisely the one chosen as a case study. The project is the "Brebex" solar power plant, whose implementation is planned in the municipality of Dimitrovgrad, near the border with Bulgaria. In this part of the book, the results of the Strategic Environmental Assessment Report of the Detailed Regulation Plan for the "Brebex" Solar Power Plant Area (2023) are used.

2 SEA was introduced into the planning practice in the Republic of Serbia with the adoption of the Environmental Protection Law. According to Article 35 of this law, "Strategic Environmental Assessment is carried out for plans, programs, and bases in the fields of spatial and urban planning or land use, energy, industry, transport, waste management, water management, and other areas and is an integral part of the plan, program, or basis." Simultaneously with this systemic law, a specific Law on Strategic Environmental Assessment was adopted ("Official Gazette of RS", number 135/2004 and 88/2010).

Slede osnovni razlozi da se upravo solarna elektrana Brebeks uzme kao studija slučaja:

- sprecifičnost bioloških i predeonih odlika, zbog čega je projekat bio posebno izazovan sa aspekta primene SPU i primene principa preventivne zaštite;
- prostorni obuhvat projekta i značajna instalisana snaga od oko 200 MW, što ga čini jednim od najvećih solarnih panela koji je do sada planiran u Srbiji;
- postojanje obilja podataka o biodiverzitetu i prostoru, koji su prikupljeni kontinuiranim opservacijama, zbog čega će čitaoci ove knjige imati bolji uvid u sistematski pristup izradi SPU;
- investitor projekta *Sage Solutions d.o.o.* Beograd pokazao je izuzetno razumevanje za važnost primene principa preventivne zaštite životne sredine zalaganjem za sprovođenje svih postupaka kojima se obezbeđuje ovakav pristup, što je omogućilo podizanje standarda u primeni SPU za solarne elektrane na viši nivo.

Iako su navedenim projektom obuhvaćeni i njegovi sastavni delovi (saobraćajna infrastruktura, trafo-stanica, priključno-razvodno postrojenje, prenosna mreža i dr.), u ovom poglavlju prikazani su samo parcijalni delovi SPU koji se odnose na solarnu elektranu, odnosno solarne panele koji su prostorno/teritorijalno najdominantniji u solarnoj elektrani. Prikaz je usmeren na metodološki pristup i pojedine bitne rezultate koji su dovoljni da se stekne utisak o primeni SPU u planiranju solarnih elektrana, a određeni detalji, koji su poslovna tajna, nisu elaborirani u ovoj knjizi.

The main reasons for choosing the “Brebex” solar power plant as a case study are:

- The specificity of its biological and landscape characteristics, making the project particularly challenging in terms of applying SEA and the principle of preventive protection;
- The spatial scope of the project and its significant installed capacity of around 200 MW, making it one of the largest solar panel projects planned in Serbia to date;
- The abundance of data on biodiversity and the environment collected through continuous observations, providing readers of this book with a better understanding of the systematic approach to SEA;
- The project investor, Sage Solutions d.o.o. Belgrade, has shown exceptional understanding of the importance of applying the principle of preventive environmental protection by advocating for the implementation of all procedures ensuring this approach, thereby raising the standards of SEA application for solar power plants to a higher level.

Although the project includes its components (transport infrastructure, transformer station, distribution plant, transmission network, etc.), only partial parts of the SEA related to the solar power plant, specifically the solar panels which are spatially/territorially the most dominant part of the solar power plant, are presented in this chapter. The presentation focuses on the methodological approach and certain significant results sufficient to give an impression of the application of SEA in planning solar power plants, while specific details, which are business secrets, are not elaborated in this book.

Svaka SPU, bez obzira o kom planskom dokumentu je reč, može se sagledati kroz nekoliko ključnih delova:

- polazne osnove s prikazom planske koncepcije;
- analiza stanja životne sredine na istraživanom prostoru;
- primena semikvantitativnog ili nekog drugog metoda višekriterijumske evaluacije planskih rešenja;
- smernice za implementaciju projekta.

U ovim delovima sadržani su i svi ključni elementi primene SPU u planiranju solarne elektrane Brebeks.

Every SEA, regardless of the planning document involved, can be viewed through several key parts:

- Initial bases with the presentation of the planning concept;
- Analysis of the environmental status in the researched area;
- Application of semi-quantitative or other multi-criteria evaluation methods of planning solutions;
- Guidelines for project implementation.

These sections contain all the key elements of applying SEA in the planning of the "Brebex" solar power plant.

5.1. Polazne osnove s prikazom planske koncepcije

Prepoznavši značaj i potrebu zaštite životne sredine koja može biti pod uticajem planirane solarne elektrane, na sednici Skupštine opštine Dimitrovgrad održanoj dana 07.04.2023. godine, a na osnovu Mišljenja opštinske Komisije za planove br. 06-70/23-17/1 od 31.03.2023, doneta je Odluka o pristupanju izradi Plana detaljne regulacije područja solarne elektrane Brebeks na teritoriji opštine Dimitrovgrad br: 06-78/2023-17/26-1 od 07.04.2023. („Službeni list opštine Dimitrovgrad", broj 06/23), u daljem tekstu: PDR. Na istoj sednici doneta je i Odluka pristupanju izradi strateške procene uticaja Plana detaljne regulacije područja solarne elektrane Brebeks na teritoriji opštine Dimitrovgrad na životnu sredinu, br: 501-49/2023-14/2 od 30.03.2023. („Službeni list opštine Dimitrovgrad", br. 06/23), u daljem tekstu: SPU. Prema navedenoj Odluci, zadatak SPU je da proceni sve moguće uticaje planskih koncepcija razvoja koje su definisane u

5.1. Initial bases in the presentation of the planning concept

Recognizing the importance and necessity of environmental protection that may be affected by the planned solar power plant, the Municipality Assembly of Dimitrovgrad, at the session held on April 7, 2023, based on the Opinion of the Municipal Planning Commission No. 06-70/23-17/1 of March 31, 2023, adopted the Decision on initiating the drafting of the Detailed Regulation Plan for the "Brebex" Solar Power Plant Area in the Dimitrovgrad municipality No. 06-78/2023-17/26-1 of April 7, 2023 ("Official Gazette of the Dimitrovgrad Municipality", No. 06/23) hereinafter: Plan. At the same session, the decision to initiate the drafting of the Strategic Environmental Assessment of the Detailed Regulation Plan for the "Brebex" Solar Power Plant Area in the Dimitrovgrad municipality on the environment, No. 501-49/2023-14/2 of March 30, 2023, ("Official Gazette of the Dimitrovgrad Municipality", No. 06/23) hereinafter: SEA. According to the mentioned Decision, the task of SEA is to assess all possible impacts of development

PDR-u, da definiše smernice za umanjenje ili eliminisanje negativnih efekata PDR-a na životnu sredinu i da prezentuje rezultate na jednostavan i nedvosmislen način kako bi se na osnovu njih donela odluka o prihvatljivosti PDR-a, odnosno projekta solarne elektrane Brebeks.

U okviru solarne elektrane planirane su dve celine, a u okviru svake više grupacija solarnih panela (solarna polja), koja su međusobno povezana internim saobraćajnicama i pratećom infrastrukturom u funkciji elektrane. Solarna polja mogu a ne moraju činiti nezavisne funkcionalne celine u smislu proizvodnje ili potrošnje električne energije i priključenja na elektroenergetski sistem Elektromreže Srbije. Ukupna snaga solarne elektrane iznosi oko 200 MW, a pojedinačna snaga solarnih panela biće definisana prilikom tehničke razrade projekta, u skladu s fazama i dinamikom realizacije, kao i tehničkim karakteristikama tipova solarnih panela koji će biti postavljeni u okviru svih ili pojedinačnih solarnih polja.

U okviru analiziranog obuhvata, PDR-om se definišu osnovne namene površina u okviru kojih se definišu pravila za izgradnju objekata u funkciji solarne elektrane i saobraćajnih i infrastrukturnih objekata u okviru površina javne i ostale namene. Planirane namene površina u obuhvatu PDR-a jesu: površine javne namene (javne saobraćajne površine – zona SP i površine za javne infrastrukturne objekte) i površine ostalih namena (površine za poljoprivrednu namenu – zone SE, P i PZ, površine za šumsko zemljište – zona Š, saobraćajne površine u okviru ostalog zemljišta – zona SPO, površina za infrastrukturne objekte u funkciji solarne elektrane – zona EE).

planning concepts defined in the Detailed Regulation Plan, to define guidelines for reducing or eliminating the negative effects of the Detailed Regulation Plan on the environment, and to present the results in a simple and unambiguous manner to make a decision on the acceptability of the Detailed Regulation Plan, or the "Brebex" solar power plant project.

Within the planned solar power plant, two units are planned, each with several groups of solar panels (solar fields) interconnected by internal roads and accompanying infrastructure serving the plant. Solar fields may, but need not, constitute independent functional units in terms of electricity production or consumption and connection to the power system of Elektromreža Srbije. The total capacity of the solar power plant is about 200 MW, and the individual capacity of the solar panels will be defined during the technical development of the project in accordance with the phases and dynamics of implementation as well as the technical characteristics of the types of solar panels to be installed within all or individual solar fields.

Within the analysed scope, the Plan defines the basic land uses within which rules for the construction of facilities for the solar power plant and transportation and infrastructure facilities within public and other areas are defined. Planned land uses within the Plan scope include: public land uses (public traffic surfaces - SP zone and surfaces for public infrastructure objects); and surfaces of other uses (surfaces for agricultural purposes - SE, P, and PZ zones, surfaces for forest land - "Š" zone, Traffic surfaces within other land - SPO zone, surfaces for infrastructure objects serving the solar power plant - EE zone).

Granicom Planskog područja obuhvaćen je deo teritorije administrativnog područja opštine Dimitrovgrad u površini od oko 700 ha severoistočno od naseljenog mesta Dimitrovgrad, uz državnu granicu sa Republikom Bugarskom, i zahvata deo katastarskih opština Bačevo, Brebevnica, Radejna i Protopopinci.

The Plan Area encompasses a part of the territory of the administrative area of the Dimitrovgrad municipality, covering an area of about 700 hectares northeast of the inhabited area of Dimitrovgrad, along the state border with the Republic of Bulgaria, and includes parts of the cadastral municipalities of Bačevo, Brebevnica, Radejna, and Protopopinci.

Slika 21. Prostorne celine u obuhvatu Plana

Figure 21. Spatial units within the Plan area

5.2. Karakteristike životne sredine na istraživanom prostoru

Postojeće stanje životne sredine predstavlja osnov za definisanje ciljeva SPU i pripadajućih indikatora, koji se zatim koriste u procesu višekriterijumske evaluacije planskih rešenja. U tom kontekstu posebna pažnja u ovoj analizi u okviru SPU posvećena je analizi svih elemenata životne sredine koji mogu biti pod uticajem svih planiranih aktivnosti u okviru kompleksa solarne elektrane.

5.2. Characteristics of the environment in the research area

The existing state of the environment serves as the basis for defining the objectives of the SEA and associated indicators, which are then used in the process of multicriteria evaluation of planning solutions. In this analysis within the SEA, special attention has been given to the analysis of all environmental elements that may be affected by all planned activities within the solar power plant complex.

5.2.1. Fizičko-geografske karakteristike prostora

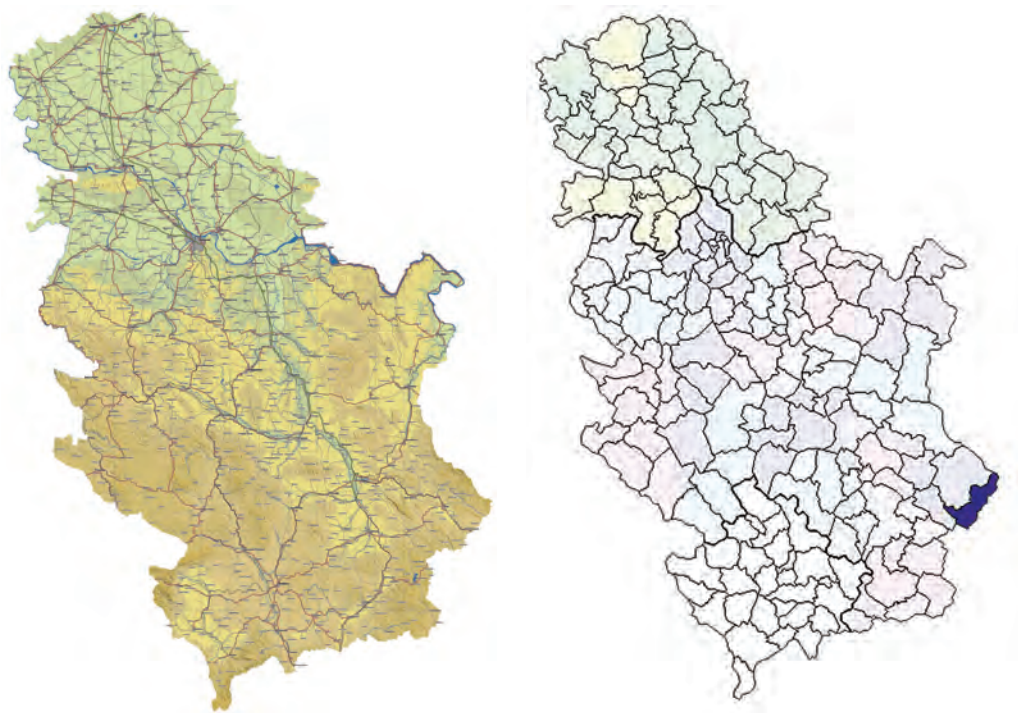
Prilikom procene teritorijalnih/prostornih uticaja određenog planskog dokumenta na životnu sredinu, potrebno je sagledati širi kontekst. Zbog toga nije dovoljno analizirati samo prostor koji je određen granicom planskog dokumenta, već i prostor van granica planskog dokumenta, što je i u ovom slučaju urađeno.

Opština Dimitrovgrad nalazi se u Istočnoj Srbiji (slika 22) i deo je Pirotskog okruga. Sedište opštine je gradsko naselje Dimitrovgrad.

5.2.1. Physical-geographical characteristics of the area

When assessing the territorial/spatial impacts of a specific planning document on the environment, it is necessary to consider the broader context. Therefore, it is not sufficient to analyse only the space delimited by the planning document boundary, but also the area beyond the planning document boundaries, which has been done in this case as well.

The municipality of Dimitrovgrad is located in Eastern Serbia (Figure 22) and is part of the Pirot District. The administrative centre of the municipality is the urban settlement of Dimitrovgrad.



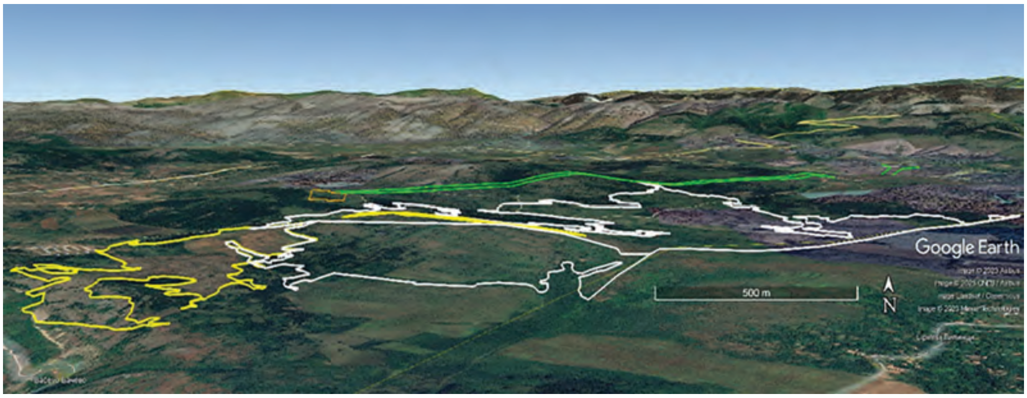
Slika 22. Geografski položaj teritorije opštine Dimitrovgrad
Figure 22. The geographical location of the territory of the municipality of Dimitrovgrad

Okolinu Dimitrovgrada čini brdsko-planinski predeo izdužen u pravcu jugozapad-severoistok. Krupni oblici reljefa prostiru se upravno na pravac pružanja teritorije. Teritoriju čini deo Gornjeg Ponišavlja, od koga se u pravcu severoistoka nastavlja Zabrđe, Vidlič i Gornji Visok. Jugozapadno od doline Nišave dominira brdsko-planinsko zemljište poznato kao Burel, Derekul i Barje, koje je na istoku ograničeno dolinom reke Lukavice, a na zapadu prosečeno klisurom Jerme. Istočno i jugoistočno dimitrovgradski kraj ograničen je teritorijom Bugarske, a na severu i severozapadu nalaze se teritorije opština Pirot i Babušnica. U celini gledano, to je brdsko-planinski kraj, kroz koji je usečen deo doline Nišave, koji je uzan i kratak, s pravcem pružanja jugoistok-severozapad. Sam grad je u središtu atara od 17,17 km².

Lokacija solarne elektrane pripada subregiji Balkanska Srbija, mezoregije Istočna Srbija, planinsko-kotlinske makroregije. Lokacija se nalazi na kraškom brdsko-planinskom terenu Zabrđa, koje predstavlja južne obronke Vidliča, najjužnijeg dela Stare planine (slika 23). Okvirne kote terena u obuhvatu lokacije kreću se od 660 do 760 m/nm, s najvišom kotom na 766 m/nm (Drbeš). Topografija terena je kompleksna a prosečan nagib terena okvirno se kreće od 10° do 20°. Veći deo lokacija nalazi se u području razvoja kraških oblika, ali obuhvata i područje umerenog spiranja i jaružanja.

The surroundings of Dimitrovgrad consist of hilly-mountainous terrain elongated in the southwest-northeast direction. Major relief forms extend perpendicular to the direction of the territory. The territory comprises part of the Upper Nisava River Basin, which extends northeastward to Zabrdje, Vidlic, and Upper Visok. Southwest of the Nisava River valley, hilly-mountainous terrain dominates, known as Burel, Derekul, and Barje, bounded to the east by the valley of the Lukavica River and to the west by the Jerma Gorge. The Dimitrovgrad area to the east and southeast is bounded by the territory of Bulgaria, while to the north and northwest are the territories of the municipalities of Pirot and Babusnica. Overall, it is a hilly-mountainous region with a section of the Nisava River valley running through it, which is narrow and short in a southeast-northwest direction. The town itself is situated in the center of an area of 17.17 km².

The location of the solar power plant belongs to the subregion of Balkan Serbia, mesoregion of Eastern Serbia, Mountain-basin macro-region. The location is situated in the karst hilly-mountainous terrain of Zabrdje, which represents the southern foothills of Vidlic, the southernmost part of the Stara Planina mountain range (Figure 23). The approximate elevation levels within the location range from 660 to 760 meters above sea level, with the highest point at 766 meters above sea level (Drbes). The terrain topography is complex, with an average slope ranging from 10° to 20°. The majority of the location is within the area of karst landforms, but it also includes areas of moderate scarping and gullies.



Slika 23. Lokacija u brdsko-planinskom predelu južnih obronaka Stare planine

(prikazane su granice lokacije aktuelne na početku monitoringa biodiverziteta (belo) i dodatne parcele uključene kasnije (žuto), a koje su u obuhvatu planskog dokumenta, kao i lokacija PRP/TS (narandžasto) i trasa dalekovoda (zelene linije)) (izvor: *Google Earth* s modifikacijom)

Figure 23. Location in the hilly-mountainous area of the southern slopes of the Stara Planina mountain

(the borders of the location are shown at the beginning of biodiversity monitoring (white) and additional parcels included later (yellow), which are within the scope of the planning document, as well as the location of PRP/TS (orange) and the route of the power lines (green lines)) (source: Google Earth with modification)

5.2.2. Prirodni kompleks

Geomorfološke karakteristike tla - reljef područja. Na analiziranom prostoru razvijen je brdsko-planinski tip reljefa. Izraženo je delovanje kraškog geomorfološkog procesa. Na površini terena vidljive su vrtače i manja kraška polja. Na delovima terena izgrađenim od klastičnih stena izraženo je površinsko spiranje i jaružanje. Najviši vrh u istražnom prostoru, Baba Luga (778 mnv), nalazi se u severoistočnom delu terena, dok se Drbeš (766 mnv) nalazi u jugozapadnom delu. Nagibi brdskih padina pretežno su 7–10°. Na prevojima su blaži nagibi oko 3–5°, dok su nagibi na kraškim zaravnima do 3°. Od padinskih procesa postojalo je delovanje deluvijalnog procesa. Klastični materijal je

5.2.2. Natural complex

Geomorphological characteristics of the soil - Relief of the area: The analysed area has developed hilly-mountainous relief. The action of karst geomorphological processes is pronounced. Sinkholes and small karst fields are visible on the terrain surface. On parts of the terrain composed of clastic rocks, surface scarping and gully erosion are evident. The highest peak in the research area is in the northeastern part of the terrain, named Baba Luga (778 meters above sea level), while in the southwestern part is Drbes (766 meters above sea level). Slopes of the hillsides are mostly 7-10°. On the passes, the slopes are gentler, around 3-5°, and on the karst plateaus, the slopes are up to 3°. Deluvial processes have affected the slopes. Clastic material has erodovan sa strmih padina i deponovan na padinama blagih nagiba.

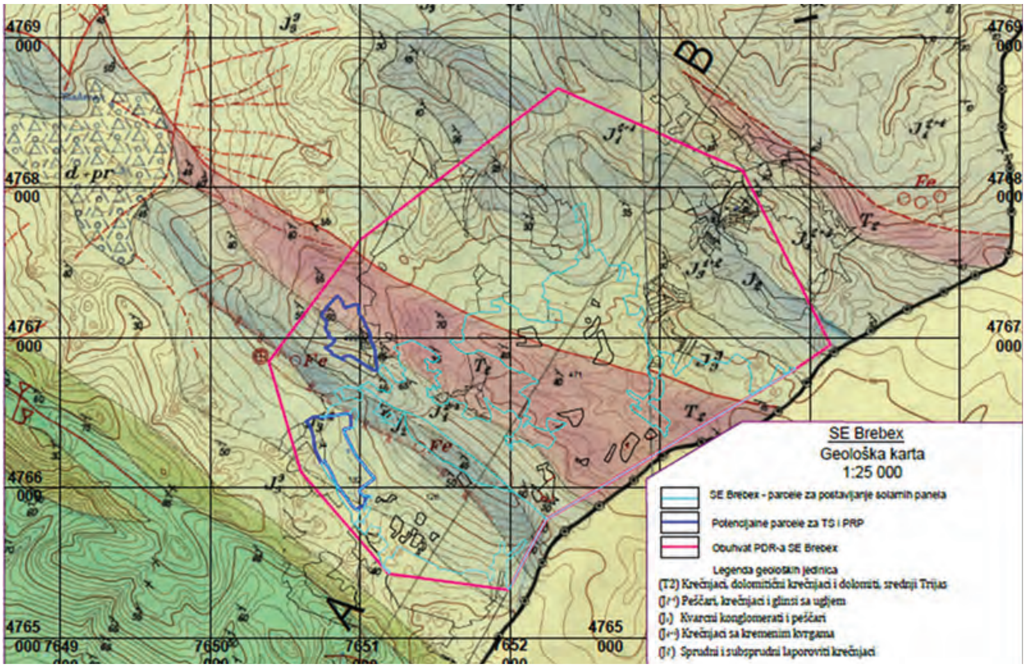
Inženjersko-geološka svojstva terena. Najveću zastupljenost na terenu (slika 24) imaju krečnjaci i dolomitični krečnjaci, zatim peščari i glinci. Kora raspadanja karbonatnih stena plitka je, procena je da se kreće do 3 m dubine. Na velikom delu terena izdanci krečnjaka vidljivi su na površini terena. Peščari i glinci su manje zastupljeni i imaju koru raspadanja u vidu zemljaste raspadine i blokova do dubine oko 5 m. Nosivost čvrstih stenskih masa veoma je dobra. Zemljasta raspadina osnovne stene stišljiva je i podložna sleganju. Pri iskopu, kad su zasecanja u širokom frontu dublja od 3 m, mora se voditi računa o merama privremenog obezbeđenja stabilnosti zbog mogućeg klizanja zemljaste raspadine i ispadanja labilnih blokova stene duž postojećih diskontinuiteta u stenskoj masi. Pristupni zemljani putevi prohodni su za terenska votila. Potrebno je proširenje, nasipanje i valjanje i izrada kanala za odvođenje vode s planuma kolovoza. Pojedini delovi puteva veoma su oštećeni usled jaružanja i spiranja sitnog materijala. Pri izgradnji novih puteva i proširenju postojećih, kosine zaseka puta visine su do 3 m.

Pojava erozije je posebno izražena u brdsko-planinskim predelima. Vidlič, odnosno najveći deo vidličke antiklinale zahvaćen je erozijom. Takođe, i najveći deo površina pašnjaka na Greben planini i Vlaškoj planini zahvaćen je erozijom, pa su pokriveni oskudnom vegetacijom. Veliki

eroded from steep slopes and deposited on gently sloping hillsides.

Engineering geological properties of the terrain - The terrain is mostly composed of limestones and dolomitic limestones, followed by sandstones and clays. The weathering crust of carbonate rocks is shallow, estimated to be up to 3 meters deep. On much of the terrain, limestone outcrops are visible on the surface. Sandstones and clays are less common and have a weathering crust in the form of earthy weathering and blocks to a depth of about 5 meters. The bearing capacity of the solid rock mass is very good. The earthy weathering of the bedrock is compressible and prone to settlement. During excavation, when the cuttings are wider than 3 meters, temporary stability measures must be taken due to the potential sliding of the earthy weathering and falling of unstable rock blocks along existing discontinuities in the rock mass. Access earth roads are passable for off-road vehicles. Expansion, embankment, compaction, and channel construction for water drainage from the road plateau are required. Some parts of the roads are heavily damaged due to gully erosion and scarping of fine material. When building new roads and expanding existing ones, the cut slope heights are up to 3 meters.

Erosion is particularly pronounced in hilly-mountainous areas. Vidlic, or most of the Vidlic anticline, is affected by erosion. Similarly, most of the pasture areas on Greben Mountain and Vlaska Mountain are affected by erosion, and they are covered with sparse vegetation. High intensity of surface erosion is observed on the right



Slika 24. Geološka karta šireg područja

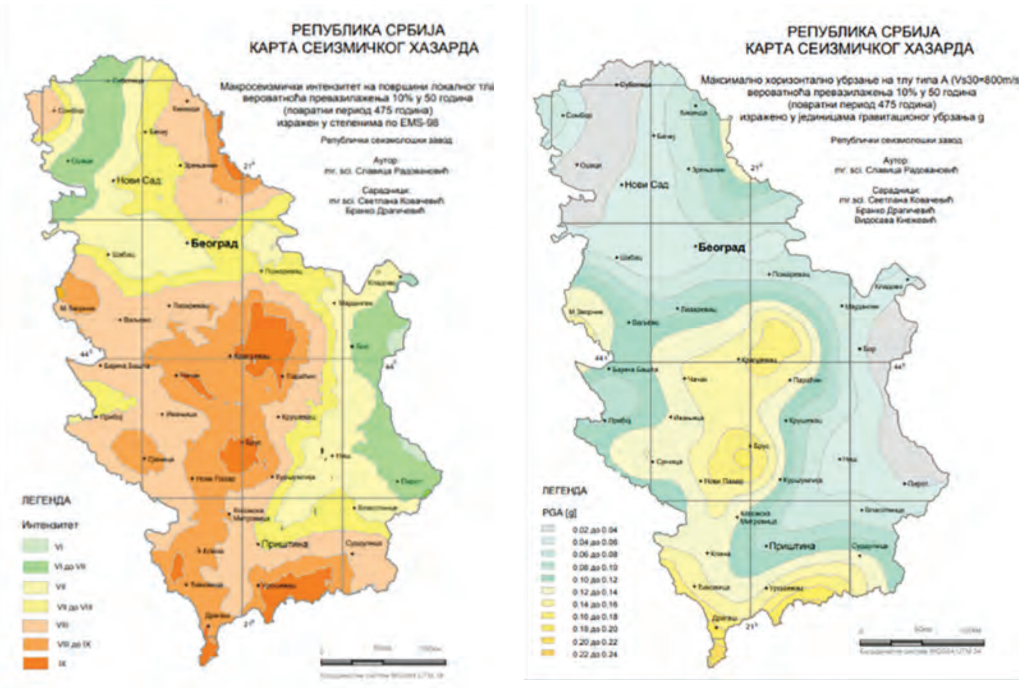
Figure 24. Geological map of the wider area

intenzitet površinske erozije uočava se na desnoj padini reke Visočice, i u slivu Jerme.

Seizmičke odlike terena. Za istražni prostor, prema priloženim kartama seizmičkog hazarda za Srbiju, makro-seizmički intenzitet na površini lokalnog tla, s verovatnoćom prevazilaženja 10% u 50 godina, za povratni period 475 godina, označen je kao VII–VIII stepeni, izraženo po EMS-98. Maksimalno horizontalno ubrzanje na tlu tipa A (Vs30=800 m/s), s verovatnoćom prevazilaženja 10% u 50 godina, za povratni period 475 godina, izražen u jedinicama gravitacionog ubrzanja (g), iznosi PGA(g)=0,04–0,06 (slika 25).

bank slope of the Visocica River, while very erosion processes occur in the Jerma River basin.

Seismic characteristics of the terrain - For the research area, according to the provided maps of seismic hazard for Serbia, the macro-seismic intensity on the surface of local soil, with a probability of exceeding 10% in 50 years, for a return period of 475 years, is VII - VIII degrees, expressed by the EMS-98. The maximum horizontal acceleration on soil type A (Vs30=800m/s), with a probability of exceeding 10% in 50 years, for a return period of 475 years, expressed in units of gravitational acceleration (g), PGA(g)=0.04-0.06 (Figure 25).



Slika 25. Seizmogeološke karte za povratni period od 475 godina

Figure 25. Seismogeological map for a return period of 475 years

Za potrebe sagledavanja seizmičkog hazarda na planskom području za Plan detaljne regulacije područja solarne elektrane Brebeks na teritoriji opštine Dimitrovgrad izrađene su:

- karta epicentara zemljotresa magnituda Mw>=3,5 jedinica Rihterove skale lociranih na planskom području,
- karta seizmičkog hazarda za povratni period 475 godina, po parametru maksimalnog horizontalnog ubrzanja na tlu tipa A (vs30>=800 m/s), izrađena u skladu sa zahtevima Evrokoda 8 (EN 1998-1), izraženo u jedinicama gravitacionog ubrzanja g (g=9.81m/s²), za plansko područje,

For the purpose of assessing seismic hazard in the planning area for the Detailed Regulation Plan of the area of the solar power plant "Brebex" on the territory of the municipality of Dimitrovgrad, the following were developed:

- Map of earthquake epicentres of magnitude Mw>=3.5 on the Richter scale located in the planning area,
- Seismic hazard map for a return period of 475 years, according to the parameter of maximum horizontal acceleration on soil type A (Vs30>=800m/s), developed in accordance with the requirements of Eurocode 8 (EN 1998-1), expressed in gravitational acceleration units g (g=9.81m/s²), for the planning area,

- karta seizmičkog hazarda za povratni period 475 godina izraženog u stepenima makroseizmičkog intenziteta zemljotresa MCS skale, izrađena na osnovu izračunatih vrednosti ubrzanja za tlo tipa A, pomnoženo faktorom tla za odgovarajuću proračunsku tačku, kako bi se obuhvatilo dejstvo zemljotresa na lokalnom tlu za šire plansko područje,
- tabela numeričkih vrednosti seizmičkog hazarda za povratni period 475 godina, po parametru maksimalnog horizontalnog ubrzanja [g] za plansko područje,
- tabela epicentara događenih zemljotresa magnituda Mw>=3,5 jedinica Rihterove skale lociranih na planskom području i u neposrednoj okolini a od uticaja za sagledavanje seizmičkog hazarda.

- Seismic hazard map for a return period of 475 years expressed in degrees of macro-seismic intensity of earthquakes on the MCS scale, prepared based on calculated values of acceleration for soil type A multiplied by the soil factor for the corresponding design point to cover the effect of earthquakes on local soil, for the wider planning area,
- Tables of numerical values of seismic hazard for a return period of 475 years according to the parameter of maximum horizontal acceleration [g], for the planning area,
- Tables of epicentres of earthquakes of magnitude Mw>=3.5 on the Richter scale located in and around the planning area, which are relevant for assessing seismic hazard.

Slika 26. Karta epicentara zemljotresa magnituda Mw>=3,5 jedinica Rihterove skale
Figure 26. Map of earthquake epicentres with magnitude Mw>=3.5 on the Richter scale

Slika 27. Karta seizmičkog hazarda za povratni period 475 godina, po parametru maksimalnog horizontalnog ubrzanja na tlu tipa A

Figure 27. Map of seismic hazard for a return period of 475 years, based on the parameter of maximum horizontal acceleration on type A soil

Slika 28. Karta seizmičkog hazarda za povratni period 475 godina izraženog u stepenima makroseizmičkog intenziteta

Figure 28. Map of seismic hazard for a return period of 475 years expressed in degrees of macro-seismic intensity

Tabela 5. Tabela numeričkih vrednosti seizmičkog hazarda za povratni period 475 godina izraženog po parametru maksimalnog horizontalnog ubrzanja [g] na tlu tipa A

Table 5. Numerical values of seismic hazard for a return period of 475 years expressed in terms of maximum horizontal acceleration [g] on type A soil

Location / Mesto	Lat	Lon	PGA (g)
Poligon 1 / Grounds 1			0.1

Tabela 6. Tabela epicentara događenih zemljotresa magnitude Mw>=3,5 jedinica Rihterove skale lociranih na planskom području i u neposrednoj okolini

Table 6. Epicentres of earthquakes with magnitude Mw>=3.5 on the Richter scale located in or in the immediate vicinity of the planning area

God / Year	Mes / Month	Dan / Day	Čas / Hr	Min	Sek / Sec	Lat	Lon	Dubina / Depth	Mw
2006	5	10	7	29	57	43.061	22.814	8	3.8

Urbanističke mere zaštite za vrstu objekata čija se izgradnja planira u obuhvatu ovog Plana odnose se na poštovanje sistema izgradnje, spratnosti objekata i mreža neizgrađenih površina, obezbeđenje slobodnih površina i prohodnosti.

Tehničke mere zaštite ogledaju se u poštovanju propisa za projektovanje i izgradnju objekata u seizmičkim područjima.

Klima. Na području opštine uglavnom se ispoljava umereno-kontinentalni klimatski tip. Prema merenjima hidrometeorološke stanice u Dimitrovgradu, zabeležena je sledeća srednja temperatura tokom godine u stepenima: zima 1,1; proleće 9,5; leto 18,8; jesen 11. Najhladniji mesec je januar, sa srednjom mesečnom temperaturom od 1,3 C^0, a najtopliji mesec jun sa 21 C^0. Godišnja temperaturna amplituda u proseku je 18,8 C^0. Prosečno, godišnje su zabeleženo najmanje 64 ledena dana, a najviše 120, od kojih 14 dana u proseku ima temperature ispod –10 C^0. Relativna vlažnost je 72%. Oblačnost je najveća u toku zime –68%. Jesenja je 63%, prolećna je 62% a letnja

Urban planning measures for protection, for the type of structures planned within the scope of this Plan, relate to compliance with construction systems, building height, network of undeveloped areas, provision of open spaces, and accessibility.

Technical protection measures are reflected in compliance with regulations for the design and construction of structures in seismic areas.

Climate - The area of the Municipality generally exhibits a moderate continental climate type. According to measurements from the meteorological station in Dimitrovgrad, the average temperatures throughout the year are: winter 1.1; spring 9.5; summer 18.8; autumn 11. The coldest month is January, with an average monthly temperature of 1.3°C, and the warmest month is June with 21°C. The annual temperature amplitude is on average 18.8°C. On average, there are at least 64 and up to 120 frosty days per year, with 14 days on average below -10°C. The relative humidity is 72%. Cloud cover is highest during winter - 68%. Autumn is 63%, spring is 62%, and summer is 38%, which correlates with the movement of air

38%, što se podudara s kretanjem relativne zasićenosti vazduha vlagom. Najkišovitija godišnja doba jesu leto i jesen, dok su zima i proleće godišnja doba s najmanjom količinom padavina. Vetar je veoma važan element podneblja ovog područja jer utiče na temperaturu vazduha, njegovu vlažnost, isparavanje i količinu padavina. Izrazito dominiraju vetrovi iz jugoistočnog, istočnog i severoistočnog pravca, dok vetrovi sa zapada duvaju uglavnom samo u julu i avgustu.

Prirodne pogodnosti za korišćenje solarne energije. Mogućnost korišćenja solarne energije na teritoriji opštine Dimitrovgrad velika je na površinama nagnutim za 60° i 30° prema jugu, (4,2–4,4 i 4,6–4,8 kWh/m^2), kao i na površinama nagnutim pod uglom geografske širine prema jugu prema podacima za januar i juli (preko 6,2 u julu i između 2,4 i 2,6 kWh/m^2 u januaru), s nešto manjim ali značajnim potencijalom kad je reč ohorizontalnim površinama (1,3–1,4 u januaru i 6,3–6,4 kWh/m^2 u julu).

Pedološke karakteristike. Zahvaljujući složenosti reljefa, geološkoj građi, klimi, vegetaciji, hidrografskim osobinama i uticaju drugih pedogenetskih faktora, na relativno malom prostoru opštine Dimitrovgrad formirali su se raznovrsni genetski tipovi zemljišta. Terenskim i laboratorijskim ispitivanjima ustanovljena su sledeća zemljišta: smonice, degradirane smonice, parapodzol (na ravnom terenu Odorovskog polja), livadsko zemljište (u Odorovskom polju pored vodotoka), mineralno barsko zemljište (na najnižim delovima Odorovskog polja koji preko cele godine pate od preteranog vlaženja), smeđe rudo zemljište na krečnjaku, smeđe zemljište na peščarima, crveno rudo zemljište ili crvenica na krečnjacima (u karstu Tepoša i Vidliča i u karstnim depresijama Radejne i Petrlaša), deluvijum (podnožje Vidliča) i skeletoidno zemljište.

humidity saturation. The rainiest seasons are summer and autumn, while winter and spring are the seasons with the least rainfall. Wind is a very important element of the region's climate as it affects air temperature, humidity, evaporation, and precipitation. Winds predominantly come from the southeast, east, and northeast directions, while winds from the west blow mainly in July and August.

Natural Advantages for Using Solar Energy. The potential for utilizing solar energy in the municipality of Dimitrovgrad is significant on surfaces inclined at 60° and 30° towards the south (4.2–4.4 and 4.6–4.8 kWh/m²), as well as on surfaces inclined at the angle of geographic latitude towards the south, according to data for January and July (over 6.2 kWh/m² in July and between 2.4 and 2.6 kWh/m² in January). There is also a slightly lower but still notable potential for horizontal surfaces (1.3–1.4 kWh/m² in January and 6.3–6.4 kWh/m² in July).

Pedological characteristics - Due to the complexity of relief, geological structure, climate, vegetation, hydrographic features, and the influence of other pedogenetic factors, various genetic soil types have formed on the relatively small area of the Municipality of Dimitrovgrad. Field and laboratory investigations have identified the following soils: chernozems, degraded chernozems, parapodzolic soils (on flat terrain of Odorovo field), meadow soils (in Odorovo field near watercourses), mineral marsh soils (in the lowest parts of Odorovo field, which suffer from excessive moisture throughout the year), brown forest soil on limestone, brown soil on sandstones, red soil or redness on limestones (in the karst of Tepoš and Vidlič and in the karst depressions of Radejna and Petrlaš), colluvium (foothills of Vidlič), and skeletal soil.

Natural advantages for using solar energy – The potential for utilizing solar energy in the territory of Dimitrovgrad municipality is significant (average 4.2–6.2Wh/m²), *Prirodne pogodnosti za korišćenje solarne energije*. Mogućnost korišćenja solarne energije na teritoriji opštine Dimitrovgrada velika je (prosečno 4,2–6,2Wh/m^2), u zavisnosti od ekspozicije solarnih panela i perioda godine.

Hidrografske karakteristike. Najveći vodotoci na teritoriji opštine Dmitrovgrad jesu Nišava, Lukavačka (Gaberska) reka s pritokama Goindolski i Željuški potok i Bele vode, deo Jerme sa izrazito bujičnom levom pritokom Kusovranskim potokom i desnim pritokama Poganovski i Košindolski (Bobotan) potok i Visočice s desnom pritokom Kameničkom rekom. Na osnovu Uredbe o kategorizaciji vodotoka, vodotoci na teritoriji opštine svrstani su u sledeće klase: reka Nišava: od bugarske granice do Dimitrovgrada – II klasa; od Dimitrovgrada do ušća Temske – IIb klasa; Gaberska reka – voda I reda; reka Jerma, od bugarske granice do ušća u Nišavu – II klasa; i reka Visočica, od izvorišta do ušća u Temsku – I klasa.

depending on the exposure of the solar panels and the time of year.

Hydrographic characteristics - The largest watercourses in the Municipality of Dimitrovgrad are the Nišava River, Lukavačka (Gaberska) River with tributaries Goindolski and Željuški streams and Bele Vode, part of the Jerma River with an extremely torrential left tributary Kusovranski stream and right tributaries Poganovski and Košindolski (Bobotan) streams, and the Visočica River with the right tributary Kamenička River. According to the Regulation on the Categorization of Watercourses, the watercourses in the Municipality are classified into the following classes: Nišava River: from the Bulgarian border to Dimitrovgrad – II class; from Dimitrovgrad to the mouth of the Temska River – IIb class; Gaberska River – I order water; Jerma River, from the Bulgarian border to the mouth into the Nišava River – II class; and Visočica River, from the source to the mouth into the Temska River – I class.

5.2.3. Prirodne vrednosti

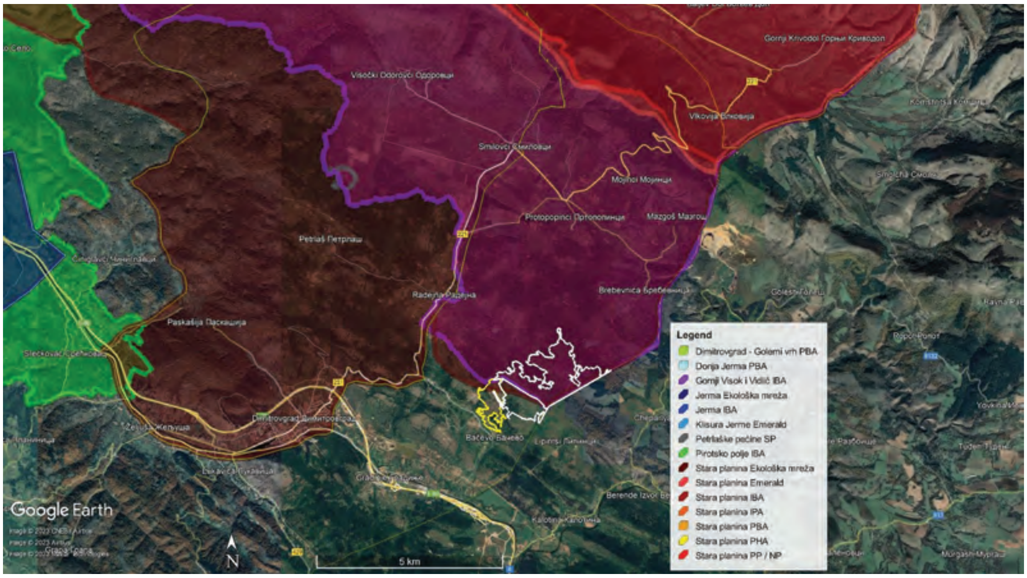
5.2.3.1. Zaštićena područja i elementi ekoloških mreža

Na planskom području *nema zaštićenih područja*, uključujući ona za koje je pokrenut postupak zaštite (slika 29), što je konstatovano i u Rešenju o uslovima zaštite prirode. Veći deo lokacije SE, međutim, obuhvaćen je granicama ekološki značajnog područja Ekološke mreže Srbije Stara planina i IBA područja Gronji Visok i Vidlič. U širem okruženju lokacije nalazi se još nekoliko ekološki značajnih područja Ekološke mreže Srbije i elemenata drugih ekoloških mreža, kao i nekolicina zaštićenih područja.

5.2.3. Natural values

5.2.3.1. Protected areas and elements of ecological networks

There are no protected areas within the planning area, including those for which the protection procedure has been initiated (Figure 29), as confirmed in the Decision on Nature Protection Conditions. However, a larger part of the solar power plant location is encompassed by the boundaries of the ecologically significant area of the Ecological Network of Serbia - Stara planina (Old Mountain) and the Important Bird and Biodiversity Area (IBA) of Gornji Visok and Vidlič. In the wider surroundings of the location, there are several other ecologically significant areas of the Ecological Network of Serbia and elements of other ecological networks, as well as a few protected areas.



Slika 29. Lokacija solarne elektrane Brebeks (oivičena belo i žuto) u regionu Istočne Srbije i u okviru potencijalne zone uticaja projekta

Figure 29. Location of the "Brebex" solar power plant (bordered in white and yellow) in the region of Eastern Serbia and within the potential impact zone of the project

Lokacije se nalaze na južnim obroncima velikog planinskog venca Stare planine, koji se duž državne granice Srbije i Bugarske pruža u pravcu severozapad–jugoistok. Stara planina je kompleksne geološke građe. Čine je škriljci, peščari i kredni krečnjaci i odlikuje izuzetna geološka i geomorfološka raznovrsnost. Kraški oblici najzastupljeniji su na Vidliču, njenom najjužnijem delu u Srbiji, od kojih su neki zaštićeni kao spomenici prirode – npr. Petrlaške pećine. Staru planinu odlikuju i očuvani veliki kompleksi pod visokoplaninskom šumskom i pašnjačkom vegetacijom i izuzetna raznovrsnost divljeg biljnog i životinjskog sveta, gde se posebno ističe oko 1.200 vrsta biljaka, među kojima je 115 endemičnih vrsta, i 203 vrste ptica, od kojih su oko 150 gnezdarice. Zbog svega ovoga, centralni deo planinskog

The locations are situated on the southern slopes of the large mountain range of Stara planina, which extends along the state border between Serbia and Bulgaria in the northwest-southeast direction. Stara planina has a complex geological structure consisting of schists, sandstones, and cretaceous limestones and is characterized by exceptional geological and geomorphological diversity. Karst forms are most common on Vidlič, its southernmost part in Serbia, some of which are protected as natural monuments – for example, the Petrlaške Caves. Stara planina also features well-preserved large complexes of high-mountain forest and pasture vegetation and exceptional diversity of wild plant and animal species, including around 1,200 plant species, among which 115 are endemic, and 203 lanca severno od grebena Vidliča zaštićen je od 1997. kao park prirode, a od 2022. formalno je u postupku promene vrste zaštite, odnosno podizanja nivoa zaštite i proglašenja za nacionalni park. Nešto šire područje identifikovano je kao EMERALD područje, a značajno šire, koje obuhvata i delove južno od grebena Vidliča, ima status značajnog područja Ekološke mreže Srbije. Na području Stare planine identifikovana su dva IBA područja – Stara planina i Gornji visok i Vidlič, IPA područje (međunarodno značajno područje za biljke), PHA područje (odabrana područja osolikih muva), kao i dva PBA područja (odabrana područja za dnevne leptire) – Stara planina i Dimitrovgrad – Golemi vrh.

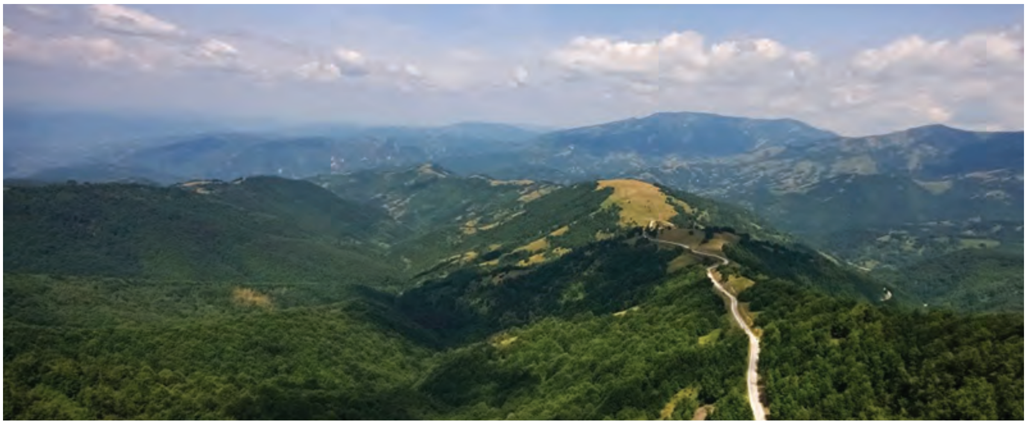
Veći deo lokacije solarne elektrane nalazi se u granicama ekološki značajnog područja Ekološke mreže Srbije Stara planina i IBA područja Gronji Visok i Vidlič (slika 30), ali lokacija zahvata krajnje male delove ovih veoma prostranih elemenata ekoloških mreža (0,12% odnosno 0,26%).

U najbližoj tački, granica PBA područja Dimitrovgrad – Golemi vrh nalazi se na oko 2 km zapadno od obuhvata Plana, a od nacionalnog parka (i EMERALD područja) na oko 6 km severoistočno, dok su svi ostali elementi ekoloških mreža Stare planine na većim udaljenostima, pa se smatra da ne postoji mogućnost izlaganja uticajima predmetne solarne elektrane. U krugu 10–20 km od lokacije nalazi se još nekoliko elemenata različitih ekoloških mreža, za koje se takođe smatra da ne postoji mogućnost da budu izloženi uticajima predmetne solarne elektrane (slika 30).

bird species, of which about 150 are nesting birds. Because of all this, the central part of the mountain range north of the Vidlič ridge has been protected since 1997 as a nature park, and since 2022, it is formally undergoing a change in the type of protection, i.e., raising the level of protection and declaring it a national park. A slightly wider area has been identified as an EMERALD area, and a significantly wider area, which also includes parts south of the Vidlič ridge, has the status of an Important Bird and Biodiversity Area of Serbia. Two IBAs – Stara planina and Gornji Visok and Vidlič, an IPA area (Internationally Important Plant Area), a PHA area (Priority Habitat for Aculeate Hymenoptera), as well as two PBA areas (Priority Butterfly Areas) – Stara planina and Dimitrovgrad - Golemi vrh have been identified in the Stara planina area.

Most of the solar power plant location is within the boundaries of the ecologically significant area of the Ecological Network of Serbia - Stara planina and the IBA of Gornji Visok and Vidlič (Figure 30), but the location covers extremely small parts of these very extensive elements of ecological networks (0.12% and 0.26%, respectively).

The nearest point, the border of the PBA area Dimitrovgrad - Golemi vrh, is about 2 km west of the Plan area, and the national park (and EMERALD area) is about 6 km northeast, with all other elements of the Stara planina ecological network at greater distances, so it is considered that there is no possibility of being affected by the solar power plant. Within a radius of about 10-20 km from the location, there are several other elements of various ecological networks, for which it is also considered that there is no possibility of being affected by the solar power plant (Figure 30).



Slika 30. Stara planina. Foto: M. Popović
Figure 30. Stara planina. Photo credit: M. Popović, original

5.2.3.2. Staništa, flora i fauna

U biogeografskom smislu lokacija se nalazi u Mezijskoj provinciji Srednjeevropskog biogeografskog regiona. Mezijsku provinciju karakteriše izvorno šumska vegetacija i umereno kontinentalna klima. U celoj provinciji višemilenijumskim antropogenim aktivnostima izvorna vegetacija i autohtoni ekosistemi veoma su redukovani, fragmentisani i transformisani, pa je današnja šumovitost (na nivou cele provincije) samo oko 30%. Najvećim delom provincije danas dominiraju poljoprivredna staništa, od kojih su u brdsko-planinskim područjima uglavnom zastupljeni pašnjaci i livade i ekstenzivne kulture. Najveći deo preostalih šumskih staništa opstao je u planinskim područjima i njima se većinom danas intenzivno gazduje, odnosno degradirana su.

Prirodna šumska staništa ostala su očuvana samo u teško pristupačnim područjima i nema ih na samoj lokacija. Budući da se lokacija delom nalazi u okviru Ekološke mreže Srbije i IBA područja, kao i u

5.2.3.2. Habitats, Flora, and Fauna

In biogeographical terms, the location is situated in the Mezeian Province of the Central European Biogeographical Region. The Mezeian Province is characterised by original forest vegetation and a moderately continental climate. Throughout the province, original vegetation and autochthonous ecosystems have been greatly reduced, fragmented, and transformed by millennia of anthropogenic activities, so today, forest cover (across the entire province) is only about 30%. For the most part, agricultural habitats dominate the province, with pastures, meadows, and extensive crops predominating in hilly and mountainous areas. Most of the remaining forest habitats have survived in mountainous areas and are mostly intensively managed today and/or degraded.

Natural forest habitats have only been preserved in areas that are difficult to access, and they are not present at the location itself. Since the location is partly within the Serbian Ecological Network and IBA (Important Bird and Biodiversity Area) sites, as well as in the vicinity of protected areas and elements of other ecological okruženju zaštićenih područja i elemenata i drugih ekoloških mreža, moguće je prisustvo za zaštitu prioritetnih tipova staništa i zaštićenih i strogo zaštićenih divljih vrsta flore i faune (Pravilnik o proglašenju i zaštiti strogo zaštićenih i zaštićenih divljih vrsta biljaka, životinja i gljiva „Službeni glasnik RS", br. 5/2010, 32/2016, 98/2016).

Na ove činjenice ukazuju i Uslovi zaštite prirode kojima je nadležni Zavod za zaštitu prirode Srbije propisao konkretne mera zaštite i očuvanja biodiverziteta, ali i obavezu razmatranja mogućih uticaja na biodiverzitet, kako na strateškom nivou tako i u sklopu Ekspertize prirodnih vrednosti područja, odnosno procene uticaja na životnu sredinu.

Preliminarna kabinetska istraživanja pokazala su da su aktuelni i relevantni javno dostupni podaci o činiocima biodiverziteta s predmetnog područja i iz neposredne okoline veoma oskudni, tako da na osnovu njih nije bilo moguće utvrditi stanje biodiverziteta.

U skladu sa Uslovima zaštite prirode i važećom zakonskom regulativom, kao i aktuelnim naučnim znanjem i najboljom međunarodnom praksom u relevantnim oblastima, za potrebe preventivne i aktivne zaštite biodiverziteta na području planirane solarne elektrane, sproveden je sveobuhvatan program prekonstrukcijskog monitoringa biodiverziteta na predmetnom području. Ovaj program uključio je kabinetska i terenska istraživanja i analize, čiji je cilj bio da se utvrdi stanje i tako omogući relevantna procena mogućih uticaja solarne elektrane na biodiverzitet, uključujući staništa, floru i faunu, posebno ornitofaunu, a realizovan je prema dinamici terenskih istraživanja/opservacija koja je prikazana u narednoj tabeli 7.

networks, there may be protected priority habitat types and protected and strictly protected wild plant and animal species present (Regulation on the Declaration and Protection of Strictly Protected and Protected Wild Plant, Animal, and Fungal Species, "Official Gazette of RS", No. 5/2010, 32/2016, 98/2016).

These facts are also indicated by the Nature Conservation Conditions under which the competent Institute for Nature Conservation of Serbia has prescribed specific measures for the protection and preservation of biodiversity, as well as the obligation to consider possible impacts on biodiversity both at the strategic level and as part of the Natural Values Expertise of the area, i.e. environmental impact assessment.

Preliminary desktop studies have shown that current and relevant publicly available data on biodiversity factors from the subject area and its immediate surroundings are very scarce, so it was not possible to determine the state of biodiversity based on them.

In accordance with the Nature Conservation Conditions and applicable legislation, as well as current scientific knowledge and best international practice in relevant fields, a comprehensive pre-construction biodiversity monitoring programme was implemented in the area of the planned solar power plant to meet the needs of preventive and active biodiversity protection. This programme included desktop and field research and analyses aimed at determining the state of biodiversity and thus enabling a relevant assessment of potential impacts of the solar power plant on biodiversity, including habitats, flora, and fauna, especially ornithofauna. It was carried out according to the schedule of field research/observations shown in the following Table 7.

Tabela 7. Dinamika terenskih istraživanja: broj dana mesečno i po istraživanju

Table 7. Field research dynamics: number of days per month and per study

Godina/Year → Mes/Mo → Metoda / Method		2023									2024			Total
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Monitoring staništa i flore / Monitoring of habitats and flora		2		2	2	2	8							16
Inventarizacija faune beskičmenjaka / Inventory of invertebrate fauna		1	1	1		2								5
Inventarizacija faune vodozemaca i gmizavaca / Inventory of amphibians and reptiles fauna		2		2	2	2	2							10
Inventarizacija faune sisara / Inventory of mammals			1		1		2				1			5
Monitoring ptica / Monitoring of birds	Cenzus gnežđenja / Nesting Census	3	3	3										9
	Cenzus gnežđenja grabljivica / Raptor nesting census	2	2	2	2									8
	Cenzus gnežđenja sova / Owl Nesting Census	1	1	1	1									4
	Istraživanja u OT / OT reserach	2	2	2	2	2	2	2	2	2	2	2	2	24

Staništa

U cilju identifikacije i vrednovanja staništa a u funkciji procene mogućih uticaja planirane solarne elektrane, sprovodena su istraživanja staništa. Inicijalno su realizovana preliminarna terenska istraživanja (rekognosciranje) i analize satelitskih snimaka, dostupne literature i postojećih izveštaja, u cilju postavljanja preciznog plana istraživanja i preliminarne analize konflikata. Detaljna terenska istraživanja u cilju precizne identifikacije i mapiranja staništa na celoj lokaciji solarne elektrane (i priključnog dalekovoda) sprovedena su nakon toga.

Staništa su identifikovana prema Pravilniku o kriterijumima za izdvajanje tipova staništa, o tipovima staništa, osetljivim, ugroženim, retkim i za zaštitu prioritetnim tipovima staništa i o merama zaštite za njihovo očuvanje („Službeni glasnik RS", broj 35/2010) i međunarodnom *EUNIS* sistemu klasifikacije, a zatim precizno locirana i digitalno mapirana pomoću *GPS* uređaja i *Google Earth Pro* softvera. Osim toga, posebno su mapirana konzervaciona vredna staništa (tj. zone koje treba izuzeti iz prostora za realizaciju projekta – princip preventivne zaštite). Lista staništa prikazana je u tabeli 8.

Habitats

In order to identify and assess habitats for the purpose of evaluating potential impacts of the planned solar power plant, habitat research has been conducted. Initially, preliminary field surveys (reconnaissance) and analysis of satellite imagery, available literature, and existing reports were carried out to establish a precise research plan and conduct preliminary conflict analysis. Detailed field research aimed at precise identification and mapping of habitats across the entire solar power plant site (including the associated transmission line) was then conducted.

Habitats were identified according to the Regulation on the Criteria for Delineating Habitat Types, Types of Habitats, Sensitive, Endangered, Rare, and Priority Habitat Types, and Measures for Their Conservation ("Official Gazette of RS", No. 35/2010) and the international EUNIS classification system. They were then precisely located and digitally mapped using GPS devices and Google Earth Pro software. Additionally, habitats of conservation value were specifically mapped (i.e., areas to be excluded from the project area - the principle of preventive protection). The list of habitats is presented in Table 8.

Tabela 8. Preliminarna lista staništa lokacije solarne elektrane Brebeks

Table 8. Preliminary list of habitats at the 'Brebex' solar power plant site

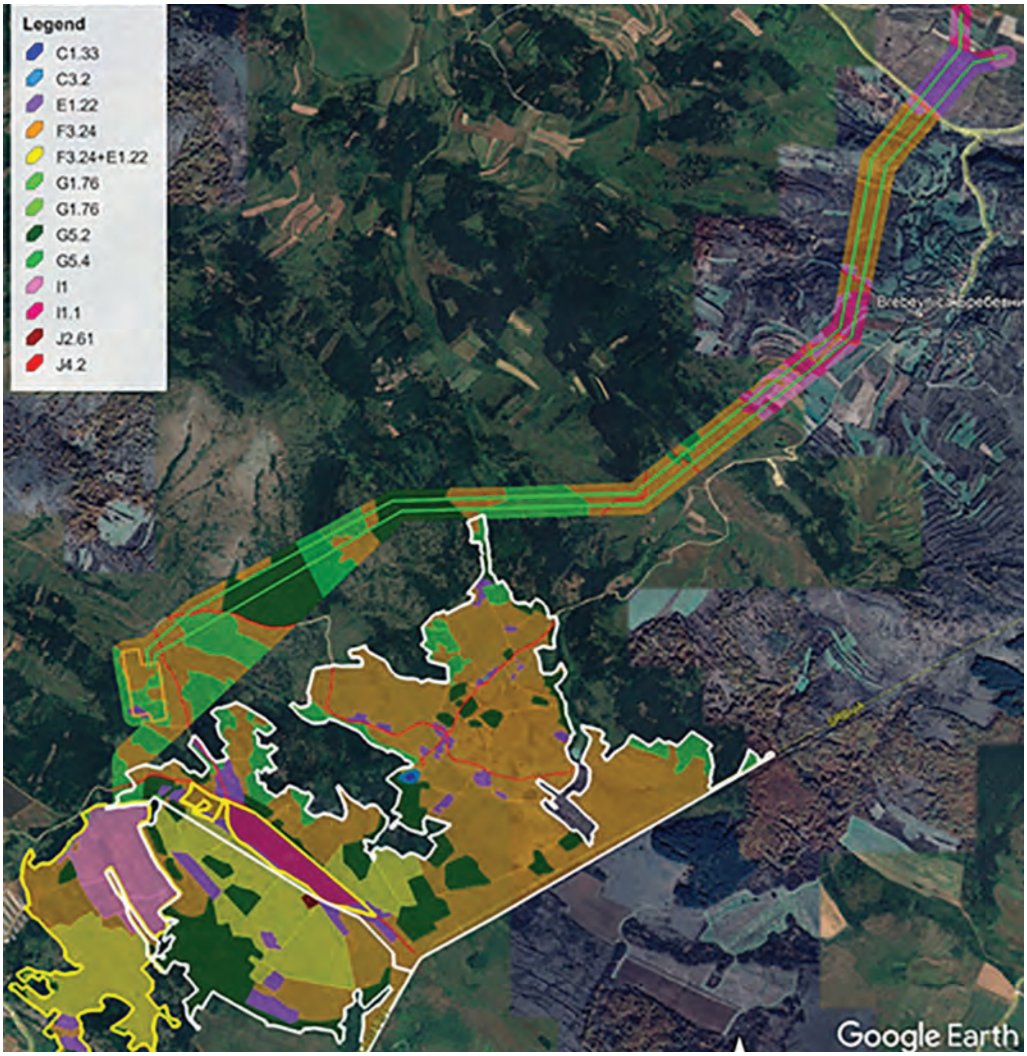
EUNIS (2017) klasifikacija / classification		Nacionalna klasifikacija / National Classification	
Kod/ Code	**Naziv / Name**	**Kod/ Code**	**Naziv / Name**
C1.33	Rooted submerged vegetation of eutrophic waterbodies	F1.334	Zajednice submerznog i eutrofnih stajaćih voda Communities of submerged pondweed (Potamogeton ssp.) of eutrophic standing waters
C3.2	Water-fringing reedbeds and tall helophytes other than canes	F3.12	Obalni tršćaci i zajednice drugih visokih helofita / Coastal reed beds and communities of other tall helophytes
E1.22	Arid subcontinental steppic grassland *(Festucion valesiacae*)	C1.32	Suve karbonatne livade i kamenjari / Dry calcareous grasslands and rocky outcrops
		C1.322	Suva karbonatna livada đipovine / Dry calcareous grassland of Đipovina (Chrysopogon gryllus)
		C1.323	Suva karbonatna livada belešine / Dry calcareous grassland of Belešina (Andropogon ishaemum)
		C1.324	Suva karbonatna livada šilje / Dry calcareous grassland of Šilje (Danthonia calycina
		C1.328	Suvi karbonatni kamenjar lepog kovilja (*Stipa pulcherrima*) / Dry calcareous rocky outcrop of beautiful feather grass
		C1.321	Suva karbonatna livada velškog vijuka (*Festuca gr. valesiaca*) / Dry calcareous grassland of Welsh fescue
F3.24	Subcontinental and continental deciduous thickets	B2.1	Kserofilni šibljaci / Xerophilous scrublands
		B2.131	Šibljak gloga (*Crataegus* spp.) / Hawthorn scrub
		B2.1E	Šibljaci trnjine (*Prunus spinosa*) / Blackthorn scrubs
		B2.5	Kserofilne šikare / Xerophilous thickets
G1.76	Balkano-Anatolian thermophilous *Quercus* forests	A2.11	Šume sladuna (*Quercus frainetto*) i cera (*Quercus cerris*) / Forests of Hungarian oak and Turkey oak
G5.2	Small broadleaved deciduous anthropogenic woodlands	AA.12	Širokolisni kserofilni šumarci / Broad-leaved xerophilous woodlands
G5.4	Small coniferous anthropogenic woodlands	A7.114	Šumski zasad crnog bora (*Pinus nigra*) / Plantation of black pine
I1	Arable land and market gardens	G1.6	Veštačke livade / Artificial meadows
I1.1	Intensive unmixed crops	G1.1	Intenzivno obrađivane otvorene njive i povrtnjaci / Intensively cultivated open fields and vegetable gardens
J2.61	Derelict spaces of disused rural constructions	H2	Retke građevine / Rare buildings
J4.2	Road networks	H8.22	Putevi / Roads

Na slici 31 prikazani su osnovni elementi inicijalne varijante prostorne organizacije kompleksa solarne elektrane: lokacija solarne elektrane (uokvireno belo i žuto), PRP/TS (narandžasto) i trasa dalekovoda (zelene linije).

Lokaciju karakteriše mozaičan sklop termofilnih žbunastih i travnih staništa (slika 32).

In Figure 31, the basic elements of the initial variant of the spatial organization of the solar power plant complex are shown: the location of the solar power plant (bordered in white and yellow), PRP/TS (orange), and the power line route (green lines).

The location is characterized by a mosaic of thermophilic shrub and grassland habitats (Figure 32).



Slika 31. Preliminarna mapa staništa lokacije solarne elektrane Brebeks (izvor: *GoogleEarth* 2023, s modifikacijama U. Buzurović, I. i B. Karapandža)

Figure 31. Preliminary habitat map of the solar power plant site “Brebex”. Source: GoogleEarth 2023, with modifications by U. Buzurović, I. and B. Karapandža

Slika 32. Mozaik termofilnih žbunastih i travnih staništa karakterističan za lokaciju. Foto: U. Buzurović

Figure 32. A mosaic of thermophilic shrub and grassland habitats is characteristic of the location. Photo credit: U. Buzurović

Šume, uglavnom termofilne šume hrastova – sladuna (*Quercus frainetto*) i cera (*Quercus cerris*) (slika 33), izvorno su stanište na predmetnom području. Površine pod različitim tipovima šumskih staništa čine manje od 20% celokupne površine lokacije solarne elektrane. Najveći deo šumskih staništa (oko 3/4) na lokaciji, međutim, izrazito su degradirani mali fragmenti, koji se klasifikuju kao šumarci i koji imaju ograničenu ekološku i konzervacionu vrednost. Ipak, i ovakva degradirana šumska staništa mogu da budu bar donekle važna za pojedine vrste flore i faune od konzervacionog značaja.

Forests, mainly thermophilic oak forests – turkey oak (Quercus frainetto) and turkey oak (Quercus cerris) (Figure 33), are the original habitats in the subject area. Areas under different types of forest habitats account for less than 20% of the total area of the solar power plant site. However, the majority of forest habitats (about 3/4) at the location are highly degraded small fragments classified as woodlands, which have limited ecological and conservation value. Nevertheless, even such degraded forest habitats can be somewhat important for certain species of flora and fauna of conservation significance.

Slika 33. Šume na lokaciji su najvećim delom veoma degradirani fragmenti. Foto: U. Buzurović

Figure 33. Forests at the location are mostly highly degraded fragments. Photo credit: U. Buzurović

Manje od 25% površine pod šumama na lokaciji (dakle, manje od 5% ukupne površine lokacije) čine nešto starija i donekle očuvanija šumska staništa (slika 34), koja odlikuje izvesna ekološka i konzervaciona vrednost. Takva nešto očuvanija šumska staništa potencijalno su važna za određene ugrožene, osetljive i zaštićene vrste flore i faune. Ovakva nešto vrednija šumska staništa zastupljena su isključivo u rubnim delovima lokacije i predstavljaju rubne delove nešto većih takvih šumskih kompleksa u okolini lokacije. Starih šumskih staništa u (skoro) prirodnom stanju, kakva odlikuje visoka ekološka i konzervaciona vrednost, kao i visoka važnost za očuvanje flore i faune, na lokaciji ni u okolini nema.

Less than 25% of the area under forests at the location (i.e., less than 5% of the total area of the site) consists of somewhat older and somewhat preserved forest habitats (Figure 34), characterized by some ecological and conservation value. Such somewhat preserved forest habitats are potentially important for certain endangered, sensitive, and protected species of flora and fauna. These somewhat more valuable forest habitats are represented only in the peripheral parts of the location and represent peripheral parts of larger forest complexes in the vicinity of the location. There are no old-growth forests in (almost) natural condition, which are characterized by high ecological and conservation value as well as high importance for preserving flora and fauna, neither at the location nor in the vicinity.

Slika 34. Nešto vredniji i donekle očuvaniji fragmenti termofilnih šuma hrastova zastupljeni su na lokaciji samo u rubnim delovima. Foto: U. Buzurović

Figure 34. Somewhat more valuable and somewhat preserved fragments of thermophilic oak forests are present at the location only in peripheral parts. Photo credit: U. Buzurović

Termofilne šume sladuna (*Quercus frainetto*) i cera (*Quercus cerris*) definisane su domaćim propisima kao za zaštitu prioritetni tipovi staništa i nalaze se na listi Priloga I EU Direktive o staništima (*Official Journal of EU* [1992/43/EEC]), tj. imaju status Natura 2000 staništa (sa kodom 91M0).

Thermophilic oak forests (Quercus frainetto and Quercus cerris) are defined by domestic regulations as priority habitat types for protection and are listed in Annex I of the EU Habitats Directive (Official Journal of the EU [1992/43/EEC]), i.e., they have Natura 2000 habitat status (with code 91M0).

Slika 35. Žbunjaci nastali sukcesijom zapuštenih livada najzastupljeniji su tip staništa na lokaciji. Foto: U. Buzurović

Figure 35. Scrubland resulting from the succession of abandoned meadows is the most represented habitat type at the location. Photo credit: U. Buzurović

Od šumskih staništa, na lokaciji su mnogo zastupljeniji drugi (polu)prirodni tipovi staništa – žbunasti i travni. To su uglavnom (zaparložene) poljoprivredne površine (livade i pašnjaci) u različitim fazama sukcesije, koje formiraju mozaik karakterističan za lokaciju. Površine staništa koja se mogu jasno klasifikovati kao žbunasta (slika 35) čine oko 50% celokupne površine lokacije, travna (održavane livade, slika 36) čine oko 5%, dok 15–20% predstavljaju površine s mozaikom u kom se elementi travnih i žbunastih staništa smenjuju na malim površinama.

Najveći deo ovih staništa ima ograničenu ekološku i konzervacionu vrednost, ali ipak mogu da budu bar donekle važne za pojedine, manje specijalizovane,vrste od konzervacionog značaja, pa je tako i većina vrsta flore i faune od konzervacionog značaja prisutnih na lokaciji vezana za mozaik žbunastih i travnih staništa.

Of the forest habitats, other (semi)natural habitat types - scrubland and grassland - are much more represented at the location. These are mainly (abandoned) agricultural areas (meadows and pastures) in various stages of succession that form a mosaic characteristic of the location. Areas of habitats that can be clearly classified as scrubland (Figure 35) make up about 50% of the total area of the location, grassy (maintained meadows, Figure 36) make up about 5%, while 15-20% represent areas with a mosaic in which elements of grassy and scrubland habitats alternate in small areas.

Most of these habitats have limited ecological and conservation value, but they can still be somewhat important for certain less specialized species of conservation significance. Thus, most species of flora and fauna of conservation significance present at the location are associated with the mosaic of scrubland and grassland habitats.

Slika 36. Održavane livade zastupljene su na lokaciji ali su srazmerno retke. Foto: U. Buzurović

Figure 36. Maintained meadows are present at the location but are relatively rare. Photo credit: U. Buzurović

U granicama lokacije nalaze se i dva mala fragmenta vodenih/vlažnih staništa – bara Lipinsko jezero (slika 37) i malo pojilo u severoistočnom delu lokacije. Oba ova fragmenta sadrže male vodene površine sa submerznom vegetacijom u centralnim delovima i obalne tršćake u litoralnim pojasevima. Ovakvi fragmenti vodenih i vlažnih staništa generički su zaštićeni i definisani su kao za zaštitu prioritetni tipovi staništa). Vodena i vlažna staništa imaju visoku konzervacionu i ekološku vrednost i važna su naročito za pojedine specijalizovane vrste, ali i za celokupnu lokalnu faunu kao izvor vode za piće.

Lipinsko jezero naročito je važno kao reproduktivni centar više vrsta vodozemaca (*Amphibia*), najvažnija lovna teritorija slepih miševa (*Chiroptera*) na lokaciji, stanište vilinskih konjica (*Odonata*), ali i za brojne druge strogo zaštićene i konzervaciono vredne vrste faune, kao i za lokalnu faunu

Within the boundaries of the location, there are also two small fragments of aquatic/moist habitats - Lipinsko Lake (Figure 37) and a small watering hole in the northeastern part of the location. Both of these fragments contain small water bodies with submerged vegetation in central parts and reedbeds in littoral zones. Such fragments of aquatic and moist habitats are generically protected and defined as priority habitat types for protection. Aquatic and moist habitats have high conservation and ecological value and are particularly important for certain specialized species, as well as for the overall local fauna as a source of drinking water.

Lipinsko Lake is especially important as a breeding ground for several species of amphibians (Amphibia), the most important hunting territory for bats (Chiroptera) at the location, a habitat for dragonflies (Odonata), as well as for numerous other strictly protected and conservationally valuable species of fauna, and for the u celini. Lipinsko jezero i malo pojilo naročito su važni kao izvor vode za piće jer na lokaciji i u okolini nema stalnih pa ni privremenih vodotokova (dve suve kraške doline na lokaciji neredovno i samo kratkotrajno poprimaju karakter bujičnih vodotokova).

local fauna as a whole. Lipinsko Lake and the small watering hole are particularly important as sources of drinking water because there are no permanent or even temporary watercourses in the location and its vicinity (two dry karst valleys at the location occasionally and only briefly take on the character of torrential watercourses).

Slika 37. Bara Lipinsko jezero. Foto: U. Buzurović

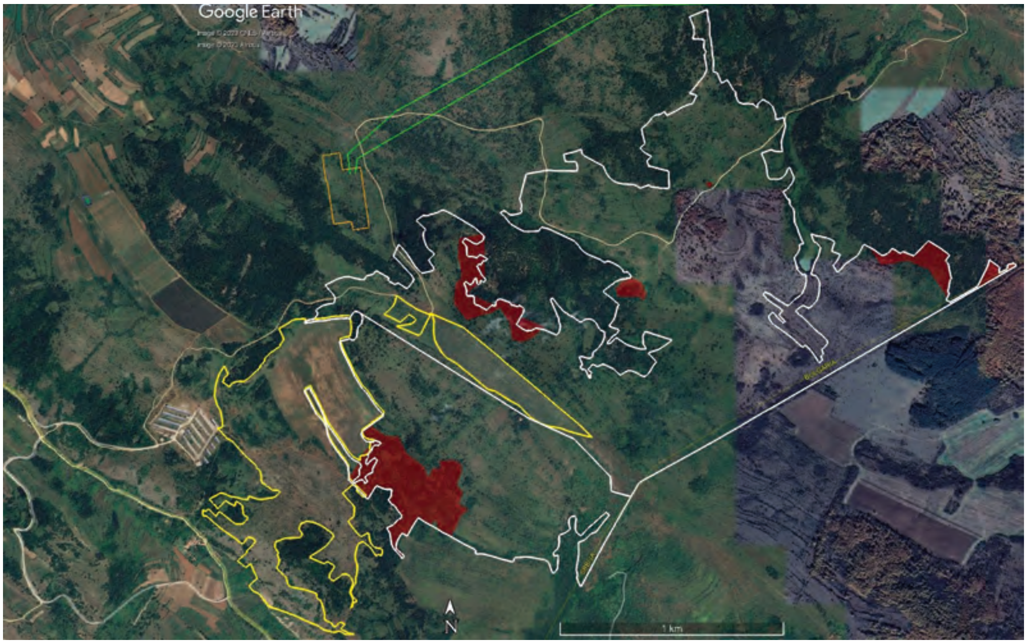
Figure 37. Lipinsko Lake. Photo credit: U. Buzurović

Na manjem delu površine lokacije (oko 8,5%) zastupljena su i kultivisana/poljoprivredna staništa koja se aktivno koriste, uglavnom veštačke livade i lucerišta.

Ova staništa nemaju konzervacioni značaj pa stoga ni konzervacionu vrednost sama po sebi. Kultivisana staništa, međutim, pružaju dopunu trofičke baze za pojedine vrste od prisutnih vrsta faune, naročito ptica i sisara.

A smaller portion of the location area (about 8.5%) is occupied by cultivated/ agricultural habitats that are actively used, mainly artificial meadows and alfalfa fields.

These habitats do not have conservation significance or value in themselves. However, cultivated habitats provide a supplement to the trophic base for certain present species of fauna, particularly birds and mammals.



Slika 38. Mapa konzervaciono vrednih staništa (poluprovidne crvene površine) na lokaciji solarne elektrane Brebeks. Prikazani su i osnovni elementi solarne elektrane (uokvireno belo i žuto), PRP/TS (narandžasto) i trasa dalekovoda (zelene linije).

Figure 38. Map of conservationally valuable habitats (semi-transparent red areas) at the solar power plant site «Brebex». Basic elements of the solar power plant (outlined in white and yellow), PRP/TS (orange), and the transmission line route (green lines) are shown.

U zoni lokacije nema naselja, ali se selo Bačevo nalazi u neposrednoj blizini. U granicama lokacije postoji samo jedan mali kompleks građevina – seosko domaćinstvo (salaš) u centralnom delu lokacije. U periodu ovog monitoringa ovo seosko domaćinstvo očigledno nije bilo aktivno već neko vreme – okućnica je zarasla a objekti pokazuju znakove propadanja.

U neposrednoj blizini lokacije nalazi se i mali napušteni kompleks vojnih objekata, čiji su objekti takođe oronuli ali još uglavnom pod krovom. Svi ovi objekti su potencijalna skloništa pojedinih vrsta slepih miševa i ptica, a ovim monitoringom zabeleženo je sklonište nekoliko jedinki malog potkovičara (*Rhinolophus hipposideros*) u jednom od vojnih objekata.

There are no settlements within the site zone, but the village of Bačevo is located in close proximity. Within the boundaries of the site, there is only one small complex of buildings – a rural household (farmstead) in the central part of the site. During this monitoring period, this rural household was clearly not active for some time – the yard was overgrown, and the buildings show signs of decay.

Near the site, there is also a small abandoned complex of military buildings, whose structures are also dilapidated but still mostly roofed. All these buildings are potential shelters for certain species of bats and birds, and this monitoring recorded a shelter for several individuals of the Lesser Horseshoe Bat (Rhinolophus hipposideros) in one of the military buildings.

Severnim rubom lokacije prolazi nekategorisani lokalni put Bačevo – Brebevnica (u nekim delovima nasut, a u nekim zemljani), a nedaleko od južne granice takođe nekategorisani lokalni put koji od državnog puta IIA reda br. 221 (Knjaževac–Dimitrovgrad) vodi do sela Bačeva (delom asfaltni a delom nasut), koji su većim delom u lošem stanju. Osim puta Bačevo – Brebevnica, na samoj lokaciji postoji još samo nekoliko zemljanih poljskih puteva.

Nekada razvijenija mreža puteva koji su služili za pristup poljoprivrednim parcelama i gazdinstvima danas je uglavnom zapuštena i većina ovih puteva nije više prohodna.

The northern edge of the site is traversed by an uncategorized local road from Bačevo to Brebevnica (partly graveled and partly earthen), and not far from the southern border, there is also an uncategorized local road that leads from the IIA state road no. 221 (Knjaževac – Dimitrovgrad) to the village of Bačevo (partly asphalt and partly graveled), which are mostly in poor condition. Besides the Bačevo – Brebevnica road, there are only a few earthen farm tracks on the site itself.

A once more developed network of roads that served to access agricultural parcels and farms is now mostly neglected, and most of these roads are no longer passable.

Flora

Preliminarnim kabinetskim istraživanjima sprovedenim u pripremnoj fazi ovog monitoringa biodiverziteta utvrđeno je da postoji nekolicina objavljenih izvora koji sadrže konkretne podatke za floru iz okruženja, ali nijedan sa same lokacije, dok nekolicina podataka s lokacije postoji u javno dostupnim bazama podataka.

U cilju utvrđivanja stanja i vrednovanja flore, a u funkciji procene mogućih uticaja planirane solarne elektrane, na lokaciji planirane solarne elektrane sproveden je celogodišnji monitoring.

Ovaj monitoring sproveden je uporedo s mapiranjem staništa na celoj lokaciji kompleksa solarne elektrane. Postavljen je i sproveden u potpunosti u skladu s najrelevantnijim i najaktuelnijim međunarodnim smernicama *IUCN* (Bennun et al, 2021) i Uslovima zaštite prirode i obuhvatao je sledeća istraživanja/metode: inventarizaciju flore i mapiranje staništa

Flora

During the preparatory phase of this biodiversity monitoring, preliminary desk studies were conducted. It was established that there are several published sources containing specific data on the flora from the surrounding area, but none from the site itself, although some data from the site are available in publicly accessible databases.

To determine the status and evaluate the flora, and in function of assessing the potential impacts of the planned solar power plant, a year-round monitoring was conducted at the site of the planned solar power plant.

This monitoring was carried out concurrently with the habitat mapping across the entire site of the solar power plant complex. It was set up and conducted entirely in accordance with the most relevant and current international guidelines of the IUCN (Bennun et al, 2021) and Conditions for Nature Conservation, and included the following research/methods: flora inventory populacija strogo zaštićenih, ugroženih i retkih vrsta.

Inventarizacija flore sprovedena je beleženjem prisutnih biljnih vrsta (a po potrebi i prikupljanjem). U slučajevima kad identifikacija biljnih taksona nije bila moguća na licu mesta, primerci biljaka su se prikupljali i kasnije identifikovali pomoću standardnih ključeva za identifikaciju flore Evrope, flore Srbije i drugih relevantnih izvora.

Detaljnim terenskim istraživanjima identifikovale su se populacije strogo zaštićenih, ugroženih i retkih vrsta i njihova staništa precizno su locirana i digitalno mapirana pomoću *GPS* uređaja i *Google Earth Pro* softvera (kako bi bila izuzeta iz prostora za realizaciju projekta).

Preliminarna lista flore, na osnovu do sad raspoloživih podataka, prikazana je u tabeli 9, koja daje i pregled statusa zaštite i ugroženosti prisutnih vrsta.

and habitat mapping of populations of strictly protected, endangered, and rare species.

The flora inventory was conducted by recording the present plant species (and collecting specimens when necessary). In cases where the identification of plant taxa was not possible on-site, plant specimens were collected and later identified using standard keys for the identification of flora in Europe, flora of Serbia, and other relevant sources.

Through detailed field studies, populations of strictly protected, endangered, and rare species were identified, and their habitats were precisely located and digitally mapped using GPS devices and Google Earth Pro software (to exclude them from the project implementation area).

The preliminary list of flora, based on data available so far, is shown in Table 9, which also provides an overview of the conservation status and vulnerability of the species present.

Tabela 9. Status zaštite i ugroženosti vrsta flore prisutnih na lokaciji

Table 9. The status of protection and endangerment of plant species present at the location

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
1	Acer campestre L. / Field Maple / klen				LC	LC	
2	Achillea millefolium L. / Common Yarrow / hajdučka trava			Z		LC	
3	Adonis vernalis L. / Pheasant's Eye / gorocvet			SZ		LC	
4	Aegonychon purpurocaeruleum (L.) Holub / Blue Hound's-tongue / rumenjak						

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
5	Agrimonia eupatoria L. / Common Agrimony / petrovac					LC	
6	Agrostis capillaris L. / Common Bent / rosulja, rudača				LC	LC	
7	Ajuga chamaepitys (L.) Schreb. / Ground Pine / ivica, mali bor						
8	Ajuga reptans L. / Bugle / ivica, puzava ivica						
9	Ajuga pyramidalis L. / Pyramidal Bugle / gorešnik piramidalni						
10	Alisma plantago-aquatica L. / Water Plantain / vodena bokvica				LC	LC	
11	Alliaria officinalis Andrz. ex DC. / Garlic Mustard / lukovac						
12	Allium carinatum L. / Keeled Garlic / -				LC	LC	
13	Allium flavum L. / Small Yellow Onion / -					LC	
14	Alopecurus pratensis L. / Meadow Foxtail / lisičji rep					LC	
15	Amaranthus retroflexus L. / Redroot Pigweed / štir						
16	Anacamptis morio (L.) R. M. Bateman, Pridgeon & M. W. Chase subsp. morio / Green-winged Orchid / kaćunak			Z		NT	
17	Anacamptis pyramidalis (L.) Rich. / Pyramidal Orchid / plaštak	I	II, IV	Z		LC	
18	Anacamptis coriophora (L.) R.M.Bateman, Pridgeon & M.W.Chase / Bug Orchid / kaćunak smrdljivi			SZ		LC	
19	Andropogon ischaemum L. / Bluestem / belešina						

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
20	Anthoxanthum odoratum L. / Sweet Vernal Grass / mirisavka						
21	Anthyllis vulneraria L. / Kidney Vetch / belodun						
22	Arctium lappa L. / Greater Burdock / čičak			Z		LC	
23	Arrhenatherum elatius (L.) P.Beauv. ex J.Presl & C.Presl / Tall Oat-grass / ovsenica					LC	
24	Artemisia vulgaris L. / Mugwort / komonika					LC	
25	Asplenium ruta-muraria L. / Wall-rue / zidna sleznica					LC	
26	Astragalus glycyphyllos L. / Wild Liquorice / orlovi nokti					LC	
27	Astragalus onobrychis L. / Sainfoin / kozinac						
28	Bellis perennis L. / Common Daisy / bela rada						
29	Betonica officinalis L. / Wood Betony / ranilist					LC	
30	Bidens tripartitus L. / Trifid Bur-marigold / kozji rogovi				LC	LC	
31	Brachypodium sylvaticum (Huds.) P.Beauv. / False-brome / šumska pasjača						
32	Briza media L. / Quaking Grass / devojačke suze						
33	Bromus erectus Huds. / Upright Brome / klasača						
34	Campanula patula L. / Spreading Bellflower / zvončić			Z			
35	Campanula persicifolia L. / Peach-leaved Bellflower / dobrodeva, zvončić						
36	Capsella bursa-pastoris (L.) Medik. / Shepherd's Purse / hoću-neću				LC		

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
37	Carex humilis Leyss. / Dwarf Sedge / niska oštrica						
38	Carex vulpina L. / Fox Sedge / lisičja oštrica				LC		
39	Carlina acaulis L. / Stemless Carline Thistle / vilino sito			Z			
40	Carthamus lanatus L. / Woolly Distaff Thistle / bodalj						
41	Centaurea orientalis L. / Eastern Knapweed / orijentalni različak, istočna zečina			SZ			
42	Centaurea phrygia L. / Wig Knapweed / kruščica						
43	Centaurium erythraea Raf. / Common Centaury / kičica			Z	LC	LC	
44	Chrysopogon gryllus (L.) Trin. / Blackseed Needlegrass / đipovina						
45	Cichorium intybus L. / Common Chicory / vodopija					LC	
46	Cirsium arvense (L.) Scop. / Creeping Thistle / palamida						
47	Clematis vitalba L. / Old Man's Beard / pavit						
48	Clinopodium vulgare L. / Wild Basil / divlji tej						
49	Consolida regalis Gray / Forking Larkspur / žavornjak						
50	Convolvulus cantabrica L. / -						
51	Convolvulus arvensis L. / Field Bindweed / poponac						
52	Cornus mas L. / Cornelian Cherry / dren			Z	LC	LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
53	Corydalis solida (L.) Clairv. / Fumewort / mlađa crvenkasta						
54	Corylus avellana L. / Common Hazel / lešnik				LC	LC	
55	Crataegus monogyna Jacq. / Common Hawthorn / glog			Z	LC	LC	
56	Crepis biennis Lapeyr. / Rough Hawk's-beard / čekinjuša crna						
57	Cruciata laevipes Opiz / Crosswort / -						
58	Cynosurus cristatus L. / Crested Dog's-tail / češljika						
59	Dactylis glomerata L. / Orchard Grass / ježevica						
60	Danthonia alpina Vest. / Alpine Oat-grass / šilj						
61	Daucus carota L. / Wild Carrot / divlja šargarepa				LC	LC	
62	Deschampsia flexuosa (L.) Trin. / Wavy Hair-grass / busika vijugava						
63	Dianthus carthusianorum L. / Carthusian Pink / -						
64	Digitalis lanata Ehrh. / Woolly Foxglove / besniče, zubačica maljava					LC	
65	Dipsacus laciniatus L. / Cut-leaved Teasel / vodostanj visoki						
66	Echinops sphaerocephalus L. / Great Globe-thistle / -						
67	Echium vulgare L. / Viper's Bugloss / lisičina						
68	Eleocharis palustris (L.) Roem. & Schult. / Common Spike-rush / močvarna sita				LC	LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
69	Elymus repens (L.) Gould / Couch Grass / pirevina				NE		
70	Erodium cicutarium (L.) L'Hér. / Common Stork's-bill / živa trava						
71	Eryngium campestre L. / Field Eryngo / vetrovalj						
72	Euonymus europaeus L. / European Spindle / uskolisna mlečika				LC	LC	
73	Euonymus latifolius (L.) Mill. / Broad-leaved Spindle / širokolisna kurika				LC	LC	
74	Euphorbia cyparissias L. / Cypress Spurge / kurika						
75	Euphrasia officinalis L. subsp. rostkoviana / Eyebright / -					LC	
76	Festuca valesiaca Schleich. ex Gaudin / Volga Fescue / -						
77	Fragaria vesca L. / Wild Strawberry / divlja jagoda			Z		LC	
78	Fraxinus ornus L. / Manna Ash / beli, gorski jasen				LC	LC	
79	Galium aparine L. / Cleavers / broćac					LC	
80	Galium mollugo L. / Hedge Bedstraw / broćac						
81	Galium purpureum DC. / Purple Bedstraw / -						
82	Galium verum L. / Lady's Bedstraw / ivanjsko cveće				LC	LC	
83	Genista sagittalis L. / Winged Broom / -				LC	LC	
84	Geranium robertianum L. / Herb Robert / živa trava			Z			
85	Geranium sanguineum L. / Bloody Cranesbill / devojačko oko, zdravinjak					LC	
86	Geum urbanum L. / Wood Avens / zečja stopa					LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
87	Glyceria maxima (Hartm.) Holmb. / Reed Sweet-grass / -				LC	LC	
88	Gymnadenia conopsea (L.) R. Br. / Fragrant Orchid / vranjak			Z		LC	
89	Helianthemum nummularium (L.) Mill. / Common Rockrose / -						
90	Helleborus odorus Waldst. & Kit. ex Willd. / Fragrant Hellebore / kukurek						
91	Himanthoglosum calcaratum (Beck) Schltr. subsp. rumelicum (H. Baumann & R. Lorenz) Niketić & Djordjević / Balkan Autumn Widow / smičak	I	II, IV	SZ			
92	Holcus lanatus L. / Yorkshire Fog / -						
93	Hordeum murinum L. / Wall Barley / popino prase				LC	LC	
94	Hypericum maculatum Crantz / Spotted St John's-wort / -			Z			
95	Hypericum perforatum L. / St John's-wort / kantarion			Z		LC	
96	Juncus effusus L. / Soft Rush / sita gola				LC	LC	
97	Juniperus communis L. / Common Juniper / kleka			Z	LC	LC	
98	Jurinea mollis (L.) Rchb. / Soft Jurinea / srebrna pilica						
99	Koeleria macrantha (Ledeb.) Schult. / Crested Hair-grass / -						
100	Lactuca muralis (L.) Fresen. / Wall Lettuce / -					LC	
101	Lathyrus latifolius L. / Broad-leaved Pea / grahorovina				LC	LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
102	Lathyrus nissolia L. / Grass Vetchling / graholika						
103	Lathyrus pratensis L. / Meadow Vetchling / graor žuti				LC		
104	Lathyrus tuberosus L. / Tuberous Pea / graor crveni krtolasti				LC	LC	
105	Lepidium draba L. / Hoary Cress / -						
106	Leucanthemum ircutianum DC. / Siberian Chrysanthemum / -						
107	Ligustrum vulgare L. / Wild Privet / kalina, zimolez						
108	Lolium multiflorum Lam. / Italian Ryegrass / talijanski ljulj					LC	
109	Lotus corniculatus L. / Bird's-foot Trefoil / zvezdan					LC	
110	Lotus herbaceus (Vill.) Jauzein / -				LC		
111	Luzula luzuloides (Lam.) Dandy & Wilmott / White Wood-rush / -						
112	Lycopus europaeus L. / Gypsywort / vučja noga, gagamija				LC	LC	
113	Lythrum salicaria L. / Purple Loosestrife / vrbičica velika				LC	LC	
114	Malus domestica Borkh. / Wild Apple / divlja jabuka						
115	Malva moschata L. / Musk Mallow / -						
116	Medicago falcata L. / Yellow Lucerne / žuta lucerka						
117	Medicago lupulina L. / Black Medick / -					LC	
118	Medicago sativa L. / Alfalfa / lucerka				LC	LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
119	Melampyrum arvense L. / Field Cow-wheat / urodica						
120	Melandrium album (Mill.) Garcke / White Campion / -						
121	Melica ciliata L. / Hairy Melick / trepuša						
122	Melilotus albus Medik. / White Sweet Clover / ždraljevina					LC	
123	Melilotus officinalis (L.) Pall. / Yellow Sweet Clover / -					LC	
124	Mentha aquatica L. / Water Mint / konjski bosiljak				LC	LC	
125	Mentha longifolia (L.) L. / Horse Mint / konjski bosiljak				LC		
126	Mentha pulegium L. / Pennyroyal / barska nana, metvica				LC	LC	
127	Muscari botryoides (L.) Mill. subsp. botryoides / Grape Hyacinth / presličica						
128	Muscari comosum (L.) Mill. / Tassel Hyacinth / -						
129	Neotinea ustulata (L.) R.M.Bateman, Pridgeon & M.W.Chase / Burnt-tip Orchid / kaćunak medeni			SZ		LC	
130	Nepeta nuda L. / Balkan Catmint / macina trava glatka						
131	Nigella arvensis L. / Field Fennel Flower / mačkovi brkovi						
132	Nonea pulla DC. / Monkswort / samak						
133	Odontites vernus (Bellardi) Dumort. / Red Bartsia / vidoka crvena						
134	Onobrychis viciifolia Scop. / Sainfoin / esparzeta				LC	LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
135	Ononis spinosa L. / Spiny Restharrow / -					LC	
136	Ophrys apifera Huds. / Bee Orchid / pčelica			SZ		LC	
137	Orchis purpurea Huds. / Lady Orchid / kaćun crveni, kaćunak purpurni, šumski kaćun			Z			
138	Orlaya grandiflora (L.) Hoffm. / White Laceflower / stidak						
139	Ornithogalum narbonense L., nom. cons. / Narbonne Star-of-Bethlehem / -						
140	Pastinaca sativa L. / Wild Parsnip / paškanat						
141	Pentanema salicinum (L.) D. Gut. Larr., Santos-Vicente, Anderb., E. Rico & M. M. Mart. Ort. / Willowleaf Yellowhead / utrenica glatka						
142	Petrorhagia prolifera (L.) P.W.Ball & Heywood / Proliferous Pink / šušuljak						
143	Phleum pratense L. / Timothy Grass / -					LC	
144	Pilosella hoppeana (Schult.) F. W. Schultz & Sch. Bip. / Hoppe's Hawkweed / -						
145	Pilosella piloselloides (Vill.) Soják / Shaggy Hawkweed / -						
146	Pinus nigra J.F.Arnold / Black Pine / crni bor				LC	LC	
147	Pinus sylvestris L. / Scots Pine / beli bor				LC	LC	
148	Plantago lanceolata L. / Ribwort Plantain / muška bokvica					LC	
149	Plantago major L. / Broadleaf Plantain / ženska bokvica				LC	LC	
150	Plantago media L. / Hoary Plantain / bokvica						

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
151	Poa angustifolia L. / Narrowleaf Bluegrass / livadarka					LC	
152	Polygala vulgaris L. / Common Milkwort / krestušac						
153	Potamogeton natans L. / Broad-leaved Pondweed / plivajuća resina				LC	LC	
154	Potentilla alba L. / White Cinquefoil / -						
155	Potentilla argentea L. / Hoary Cinquefoil / petoprsnica						
156	Potentilla erecta (L.) Raeusch. / Tormentil / -			Z		LC	
157	Primula veris L. / Cowslip / -						
158	Prunella vulgaris L. / Common Self-heal / crnjevac				LC	LC	
159	Prunus avium (L.) L. / Wild Cherry / divlja trešnja				LC	LC	
160	Prunus spinosa L. / Blackthorn / trnjina				LC	LC	
161	Prunus cerasifera Ehrh. / Cherry Plum / džanarika				DD	DD	
162	Pyrus pyraster (L.) Burgsd. / Wild Pear / divlja kruška				LC	LC	
163	Quercus cerris L. / Turkey Oak / cer				LC	LC	
164	Quercus frainetto Ten. / Hungarian Oak / sladun				LC	LC	
165	Quercus pubescens Willd. / Downy Oak / medunac				LC	LC	
166	Ranunculus garganicus Ten. / Gargano Buttercup / -						
167	Reseda lutea L. / Wild Mignonette / rezeda, katanac žuti						
168	Rhinanthus rumelicus Velen. / -						
169	Rosa agrestis Savi / Wild Rose / -					LC	
170	Rosa canina L. / Dog Rose / divlja ruža			Z		LC	

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
171	Rosa gallica L. / French Rose / -					DD	
172	Rubus caesius L. / Dewberry / divlja kupina					LC	
173	Rubus canescens DC. / -						
174	Rumex acetosa L. / Common Sorrel / kiseljak veliki						
175	Rumex acetosella L. / Sheep's Sorrel / kiseljak mali					LC	
176	Salvia aethiopis L. / Ethiopian Sage / -			Z			
177	Salvia nemorosa L. / Woodland Sage / -						
178	Salvia sclarea L. / Clary Sage / -					LC	
179	Sambucus ebulus L. / Dwarf Elder / burjan					LC	
180	Sambucus nigra L. / Black Elder / zova				LC	LC	
181	Sanguisorba minor Scop. / Salad Burnet / dinjica						
182	Scabiosa ochroleuca L. / Cream Scabious / -						
183	Schoenoplectus lacustris (L.) Palla / Lakeshore Bulrush / zuka				LC	LC	
184	Securigera varia (L.) Lassen / Crown Vetch / ajčica					LC	
185	Sedum acre L. / Goldmoss Stonecrop / žednjak					LC	
186	Senecio leucanthemifolius Poir. subsp. vernalis (Waldst. & Kit.) Greuter / -						
187	Sideritis montana L. / Mountain Ironwort / čistac			Z			
188	Silene otites (L.) Wibel / Spanish Catchfly / -						
189	Stachys germanica L. / German Hedgenettle / sjeruša						
190	Stachys recta L. / Perforate Stachys / čistac						

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
191	Stellaria media (L.) Vill. / Common Chickweed / mišjakinja					LC	
192	Stenactis annua (L.) Cass. / Annual Fleabane / krasolika						
193	Stipa capillata L. / Feather Grass / -						
194	Stipa pulcherrima K. Koch, nom. cons. prop. / Beautiful Feather Grass / -			SZ			
195	Syringa vulgaris L. / Common Lilac / jorgovan				LC	LC	
196	Taraxacum officinale F.H.Wigg. / Common Dandelion / maslačak					LC	
197	Teucrium chamaedrys L. / Wall Germander / dubačac			Z		LC	
198	Thesium divaricatum Jan ex Mert. & W. D. J. Koch / Spreading Bastard-Toadflax / lanak						
199	Thymus serpyllum L. / Wild Thyme / majčina dušica			Z	LC	LC	
200	Tragopogon dubius Scop. / Yellow Goat's Beard / kozja brada						
201	Trifolium alpestre L. / Alpine Clover / detelina gorska					LC	
202	Trifolium arvense L. / Hare's-foot Clover / zečja detelina						
203	Trifolium pannonicum Jacq. / Hungarian Clover / -						
204	Trifolium pratense L. / Red Clover / žuta gunjica				LC	LC	
205	Trifolium striatum L. / Knotted Clover / -						
206	Trifolium campestre Schreb. / Large Trefoil / engleska detelina						

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
207	Trifolium montanum L. / Mountain Clover / bela brdska detelina						
208	Trifolium repens L. / White Clover / bela detelina					LC	
209	Trinia glauca (L.) Dumort. / Glauca Trinia / -						
210	Tripleurospermum inodorum (L.) Sch. Bip. / Scentless Mayweed / rada, mali bratić						
211	Trisetum flavescens (L.) P.Beauv. / Yellow Oat-grass / ovsika				LC		
212	Ulmus minor Mill. / Field Elm / -				DD	DD	
213	Urtica dioica L. / Common Nettle / kopriva				LC	LC	
214	Verbascum phoeniceum L. / Purple Mullein / divizma modrocvetna						
215	Verbena officinalis L. / Vervain / vrbena, ljutovnica					LC	
216	Veronica polita Fr. / Grey Field-speedwell / -						
217	Veronica scutellata L. / Marsh Speedwell / verenica končasta barska				LC	LC	
218	Veronica chamaedrys L. / Germander Speedwell / zmijina trava						
219	Viburnum lantana L. / Wayfaring Tree / čibukovina						
220	Vicia cracca L. / Tufted Vetch / graorica						
221	Vicia grandiflora Scop. / Large-flowered Vetch / graorica žuta				LC	LC	
222	Vicia hirsuta (L.) Gray / Hairy Tare / graorica modrasta						
223	Vicia pannonica Crantz / Hungarian Vetch / graorica smeđa						

Br. / No.	Naziv vrste / Species name	Bern (supplement / dodato)	EU Direct. birds (supplement / dodato)	SRB zakon / Serbian law (SZ/Z)	IUCN		
					Globalno / Globally	Evropa / Europe	Srbija / Serbia
224	Vicia sativa L. / Common Vetch / -				LC	LC	
225	Vicia tenuifolia Roth / Fine-leaved Vetch / -				LC		
226	Vincetoxicum hirundinaria Medik. / Swallow-wort / divlja paprika						
227	Viola arvensis Murray / Field Pansy / poljska ljubičica					LC	
228	Viola reichenbachiana Jord. ex Boreau / Early Dog-violet / -						
229	Xanthium strumarium L. / Common Cocklebur / zelena boca						
230	Xeranthemum cylindraceum Sm. / Cylindrical Everlasting / metvica sitna						

Legenda i napomene

Bern – Bernska Konvencija o očuvanju evropske divlje flore i faune i prirodnih staništa („Službeni glasnik RS" br. 102 / 2007): Dodatak II ili III;

EU Direkt. staništa – Direktiva o očuvanju prirodnih staništa i divlje faune i flore EU (*Official Journal of EU* [1992/43/EEC]): Prilog I ili II;

SRB zakon – Zakon o zaštiti prirode RS („Službeni glasnik RS"' br. 36/2009a, 88/2010, 91/2010 – *ispravka*, 14/2016, 95/2018 – *drugi zakon*, 71/2021), Pravilnik o proglašenju i zaštiti strogo zaštićenih i zaštićenih divljih vrsta biljaka, životinja i gljiva („Službeni glasnik RS", br. 5/2010, 32/2016, 98/2016): SZ – strogo zaštićena divlja vrsta, Z – zaštićena divlja vrsta;

IUCN - IUCN (2023) kategorije: EN – ugrožena, VU – ranjiva, NT – skoro ugrožena, LC – najmanja briga, DD – nedostatak podataka, NE – nije izvršena evaluacija, n/a – nije podesna.

Legend and Notes

Bern - Bern Convention on the Conservation of European Wildlife and Natural Habitats ("Official Gazette of RS" No. 102 / 2007): Annex II or III;

EU Habitat Directive - Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora of the EU (Official Journal of the EU [1992/43/EEC]): Annex I or II;

SRB zakon - Law on Nature Protection of the Republic of Serbia ("Official Gazette of RS" No. 36/2009a, 88/2010, 91/2010 - correction, 14/2016, 95/2018 – another law, 71/2021), Regulation on the Designation and Protection of Strictly Protected and Protected Wild Species of Plants, Animals and Fungi ("Official Gazette of RS" No. 5/2010, 32/2016, 98/2016): SZ - strictly protected wild species, Z - protected wild species;

IUCN - IUCN (2023) categories: EN - endangered, VU - vulnerable, NT - near threatened, LC - least concern, DD - data deficient, NE - not evaluated, n/a - not applicable.

Na osnovu rezultata opservacija, konstatovano je da je flora šireg područja planirane solarne elektrane relativno siromašna u poređenju s konzervaciono vrednim i prepoznatim područjima važnim za floru (IPA područjima) u širem okruženju. Ipak, prisutne su pojedine konzervaciono značajne i (strogo) zaštićene biljne vrste, npr. orhideje kaćunak smrdljivi (*Anacamptis coriophora*), kaćunak (*Anacamptis morio*), plaštak (*Anacamptys piramidalis*), vranjak (*Gymnadenia conopsea*), smičak (*Himantoglossum calcaratum*), kaćunak medeni (*Neotinea ustulata), pčelica (Ophrys apifera*), i kaćun crveni (*Orchis purpurea*), kao i gorocvet (*Adonis vernalis*) i orijentalni različak (*Centaurea orientalis*).

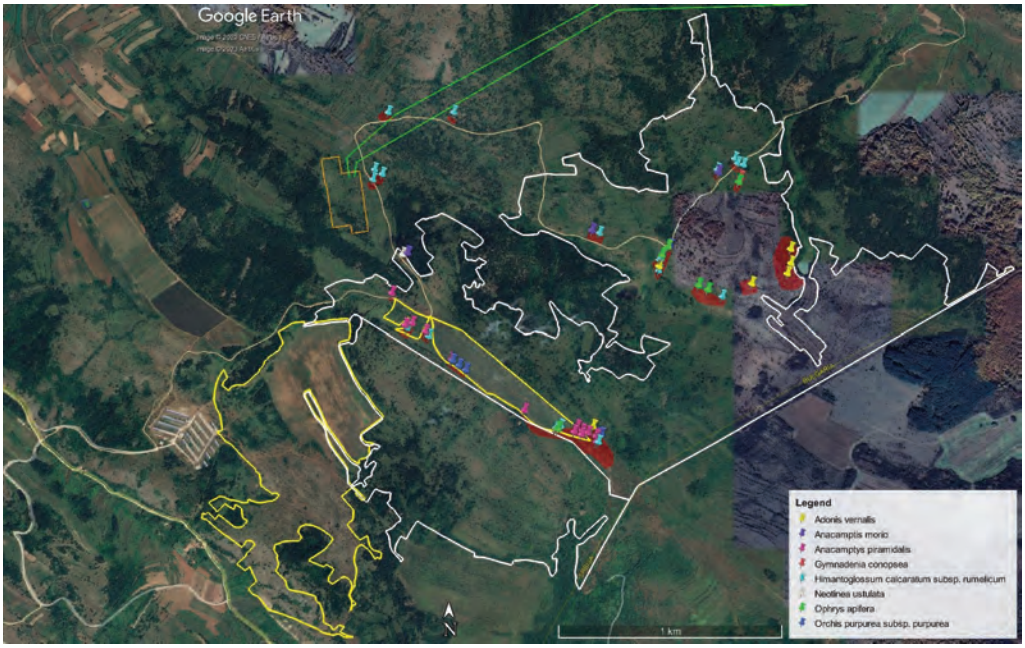
Based on the results of observations, it has been noted that the flora of the wider area around the planned solar power plant is relatively poor compared to conservationally valuable and recognized areas important for flora (IPA areas) in the wider environment. However, there are individual conservationally significant and (strictly) protected plant species present, for example, the stinking orchid (Anacamptis coriophora), green-winged orchid (Anacamptis morio), pyramidal orchid (Anacamptys pyramidalis), fragrant orchid (Gymnadenia conopsea), lizard orchid (Himantoglossum calcaratum), burnt-tip orchid (Neotinea ustulata), bee orchid (Ophrys apifera), and lady orchid (Orchis purpurea), as well as pheasant's eye (Adonis vernalis) and eastern knapweed (Centaurea orientalis).

Staništa populacija ovih vrsta detaljno su mapirana (slika 39). Osim toga, moguće je prisustvo nekoliko dodatnih ugroženih i retkih vrsta, ali će tek predstojeća istraživanja, u odgovarajućem sezonskom aspektu, moći da daju definitivnu potvrdu njihovog prisustva/odsustva, i omogućiti eventualno mapiranje staništa.

The habitats of these species' populations have been detailed mapped (Figure 39). Additionally, there may be several other endangered and rare species present, but forthcoming research, in the appropriate seasonal aspect, will be able to definitively confirm their presence/absence and potentially enable the mapping of their habitats.

Karakteristične vrste flore žbunastih staništa jesu divlja ruža (*Rosa canina* L.), glog (*Crataegus monogyna* Jacq.) i trnjina (*Prunus spinosa* L.), a travnih belešina (*Andropogon ishaemum*), đipovina (*Chrysopogon gryllus*), velški vijuk (*Festuca valesiaca*) i lepo kovilje (*Stipa pulcherrima*).

Characteristic species of the flora of shrubby habitats include wild rose (Rosa canina L.), hawthorn (Crataegus monogyna Jacq.), and blackthorn (Prunus spinosa L.), and of grassy habitats include Belešina (Andropogon ishaemum), Đipovina (Chrysopogon gryllus), Welsh fescue (Festuca valesiaca), and beautiful feather grass (Stipa pulcherrima).



Slika 39. Preliminarna mapa staništa populacija strogo zaštićenih, ugroženih i retkih vrsta flore (poluprovidne crvene površine)
(legenda: nalazi vrsta; prikazani su i osnovni elementi aktuelne varijante Plana: lokacija solarne elektrane (uokvireno belo i žuto), PRP/TS (narandžasto) i trasa dalekovoda (zelene linije)

Figure 39. Preliminary map of the habitats of populations of strictly protected, endangered, and rare flora species (semi-transparent red areas)
(Legend: species findings); the basic elements of the current version of the Plan are also shown: the location of the solar power plant (bordered in white and yellow), PRP/TS (orange), and the route of the power lines (green lines).

Fauna (izuzev ornitofaune)

Preliminarnim kabinetskim istraživanjima sprovedenim u pripremnoj fazi monitoringa biodiverziteta, utvrđeno je da u javno dostupnim bazama podataka za sve grupe faune, izuzev ornitofaune, postoji samo nekolicina konkretnih podataka s lokacije, odnosno iz relevantne neposredne okoline, dok u objavljenim izvorima takvi podaci nisu nađeni. Inventarizacija faune, izuzev ornitofaune, uglavnom se sprovodi metodom nestandardizovanih transekata, realizovanih hodanjem ili vožnjom.

Fauna (excluding birdlife)

Preliminary desk-based research conducted during the preparatory phase of the biodiversity monitoring determined that in publicly accessible databases for all faunal groups, except birdlife, there are only a few concrete data from the site and/or its immediate vicinity, while no such data were found in published sources. The inventory of fauna, excluding birdlife, is mainly conducted using the method of non-standardized transects, carried out by walking or driving. The presence

Prisustvo sisara, gmizavaca i vodozemaca beleži se na osnovu neposrednog vizuelnog ili zvučnog opažanja – posmatranja jedinki i zabeleženog karakterističnog oglašavanja, kao i na osnovu indirektnih pokazatelja prisustva – tragova, brloga, ostataka ili tragova hranjenja, odnosno drugih životnih aktivnosti. Letna aktivnost slepih miševa registruje se i audiodetekcijom njihovih eholokacijskih signala i oglašavanja pomoću manuelnog ultrazvučnog detektora (uz snimanje i analizu snimljenih signala na kompjuteru pomoću specijalizovanog softvera radi preciznije identifikacije vrsta). Prisustvo gmizavaca, vodozemaca i beskičmenjaka utvrđuje se hvatanjem primeraka pomoću ručnih mreža i različitih standardnih klopki.

Na osnovu podataka kabinetskih i terenskih istraživanja, kao i procene pogodnosti staništa i mogućnosti prisustva određenih vrsta, konstatovano je da je fauna šireg područja planirane solarne elektrane relativno siromašna, naročito u poređenju s konzervaciono vrednim zaštićenim područjima u širem okruženju, ali su, ipak, barem povremeno, prisutne pojedine konzervaciono značajne i (strogo) zaštićene vrste. Od sisara to su prevashodno sve vrste slepih miševa, budući da su strogo zaštićene, koje lokaciju uglavnom koriste u veoma malom broju kao tranzicionu i lovnu teritoriju manjeg značaja, dok se kao nešto značajnija lovna teritorija većine vrsta izdvaja samo zona Lipinskog jezera; još manji broj prisutnih jedinki slepih miševa ima skloništa na lokaciji, jer su kriptički uslovi na lokaciji veoma oskudni (stara stabla i građevine su krajnje malobrojni, a prirodnih podzemnih objekata nema). Od ostalih sisara izdvaja se još samo jedna strogo zaštićena vrsta – slepo

of mammals, reptiles, and amphibians is recorded based on direct visual or auditory observation – sighting of individuals and recorded characteristic calls, as well as based on indirect indicators of presence – tracks, burrows, remains or feeding marks and/or other life activities. The flight activity of bats is also registered using audiodetection of their echolocation signals and calls using a manual ultrasonic detector (with recording and analysis of the recorded signals on a computer using specialized software for more precise species identification). The presence of reptiles, amphibians, and invertebrates is determined by capturing specimens using hand nets and various standard traps.

Based on the data from desk and field research, as well as assessments of habitat suitability and the potential presence of certain species, it has been observed that the fauna of the wider area around the planned solar power plant is relatively poor, especially compared to conservationally valuable protected areas in the wider environment. However, at least occasionally, certain conservationally significant and (strictly) protected species are present. Among mammals, primarily all species of bats, which are strictly protected, use the location in very small numbers as a transitional and minor hunting territory. Only the area around Lipinski Lake stands out as a somewhat significant hunting territory for most species; furthermore, an even smaller number of bat individuals have shelters at the site, as cryptic conditions at the location are very scarce (old trees and buildings are extremely rare, and there are no natural underground features). Among other mammals, only one strictly protected species stands out – the blind mole rat (Nannospalax leucodon), which has been kuče (*Nannospalax leucodon*), koja je na lokaciji zabeležena u krajnje malom broju. Od gmizavaca takođe se izdvaja samo jedna do sad zabeležena strogo zaštićena vrsta – kratkonogi gušter (*Ablepharus kitaibelii*), prisutna na lokaciji u krajnje malom broju, a od vodozemaca nekoliko strogo zaštićenih vrsta žaba (*Anura*) i Burešov dugonogi veliki mrmoljak (*Triturus ivanbureschi*), sve prisutne isključivo u zoni Lipinskog jezera gde se i razmnožavaju. Konzervaciono najvredniji elementi faune beskičmenjaka jesu (domaćim odnosno međunarodnim propisima) strogo zaštićene vrste leptira – vunasta prelja (*Eriogaster catax*), veliki dukat (*Lycaena dispar*), močvarni šarenac (*Euphydryas aurinia*), mala kirinija (*Kirinia climene*) i uskršnji leptir (*Zerynthia polyxena*), kao i u Srbiji veoma retka stepska vrsta leptira *Zygaena laeta,* čiji je ovo tek četvrti nalaz kod nas. Karakteristična vrste faune sisara jesu zec (*Lepus europaeus*), lisica (*Vulpes vulpes*), srna (*Capreolus capreolus*) i brojne vrste bubojeda (*Eulipotyphla*) i glodara (*Rodentia*). Karakteristične vrste faune gmizavaca uključuju zelembaća (*Lacerta viridis*) i zidnog guštera (*Podarcis muralis*). Vodozemci su zastupljeni uglavnom u zoni Lipinskog jezera, a karakteristične vrste van ove zone jesu krastača (*Bufo bufo*) i šumska žaba (*Rana dalmatina*). Karakteristične vrste faune insekata jesu leptiri (*Lepidoptera*) vezani za mozaik termofilnih žbunastih i travnih staništa, a zastupljeni su, uglavnom u zoni Lipinskog jezera, i vilinski konjici (*Odonata*).

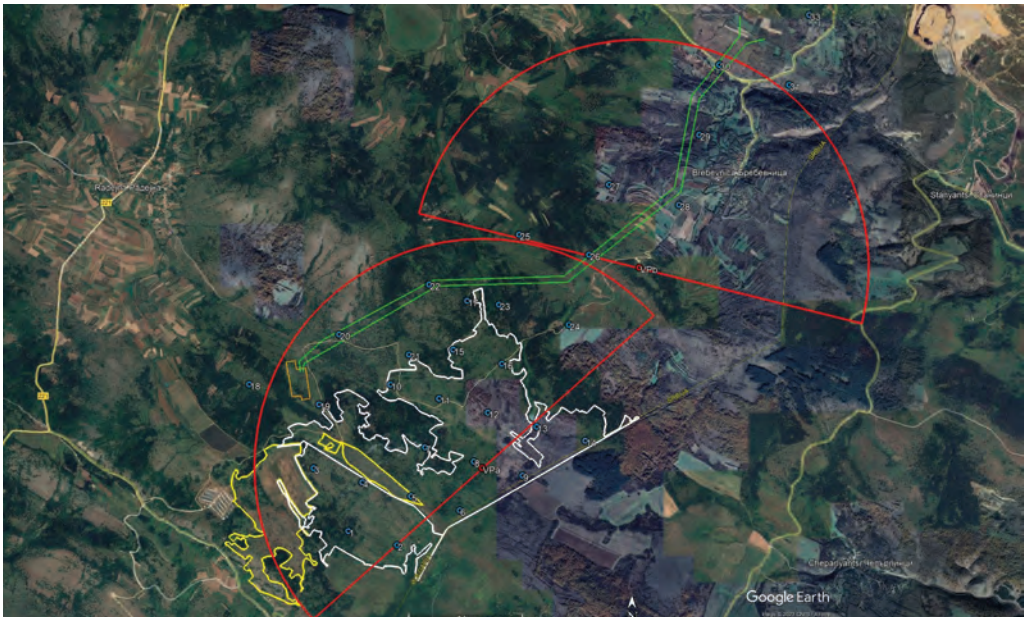
recorded at the site in extremely small numbers. Among reptiles, only one strictly protected species has been recorded so far – the short-legged lizard (Ablepharus kitaibelii), present at the site in very small numbers. Among amphibians, several strictly protected species of frogs (Anura) and the Buresh's long-legged newt (Triturus ivanbureschi) are present exclusively in the area of Lipinski Lake where they also breed. The most conservationally valuable elements of invertebrate fauna are (nationally and/or internationally) strictly protected butterfly species – the hairy caterpillar moth (Eriogaster catax), large copper (Lycaena dispar), marsh fritillary (Euphydryas aurinia), lesser purple emperor (Kirinia climene), and eastern festoon (Zerynthia polyxena), as well as the very rare steppe species Zygaena laeta, which has been recorded only four times in Serbia. Characteristic mammal fauna species include the European hare (Lepus europaeus), red fox (Vulpes vulpes), roe deer (Capreolus capreolus), and numerous species of shrews (Eulipotyphla) and rodents (Rodentia). Characteristic reptile fauna species include the European green lizard (Lacerta viridis) and the common wall lizard (Podarcis muralis). Amphibians are mostly found in the Lipinski Lake area, with the common toad (Bufo bufo) and Dalmatian frog (Rana dalmatina) being characteristic species outside this area. Characteristic insect fauna species include butterflies (Lepidoptera) associated with a mosaic of thermophilic shrubby and grassy habitats, and dragonflies (Odonata), mainly found in the Lipinski Lake area.

Ornitofauna

Preliminarnim kabinetskim istraživanjima, sprovedenim u pripremnoj fazi monitoringa biodiverziteta, utvrđeno je da u javno dostupnim bazama podataka za ornitofaunu postoji nekolicina konkretnih podataka s lokacije odnosno iz neposredne okoline, dok u objavljenim izvorima takvi podaci nisu nađeni. U cilju utvrđivanja stanja i vrednovanja ornitofaune, a u funkciji procene mogućih uticaja planirane solarne elektrane, sprovedene su kontinuirane opservacije u skladu s najrelevantnijim i najaktuelnijim međunarodnim smernicama *IUCN* i drugim referentnim dokumentima i obuhvaćena sledeća istraživanja/metode: cenzus gnežđenja uobičajenih vrsta ptica; cenzus gnežđenja grabljivica i drugih krupnijih vrsta; cenzus gnežđenja noćnih ptica (cenzus gnežđenja sova); istraživanje letne aktivnosti u osmatračkim tačkama (istraživanje u OT). Terenska postavka ovog ciklusa monitoringa prikazana je na slici 40. Ovako postavljen monitoring omogućio je potpuno sagledavanje brojnosti populacija celokupne faune ptica predmetnog područja, funkcije staništa lokacije za faunu ptica, kao i kvantifikaciju letne aktivnosti na širem području, i time osigurao pouzdanu procenu mogućih uticaja planirane solarne elektrane na ornitofaunu.

Birdlife

During the preparatory phase of biodiversity monitoring, preliminary desk-based research found that there are a few specific data available in publicly accessible databases for birdlife from the site and/or its immediate surroundings, while no such data were found in published sources. To determine the status and assess the birdlife, and in the context of evaluating potential impacts of the planned solar power plant, continuous observations were conducted in accordance with the most relevant and up-to-date international guidelines of IUCN and other reference documents. The research/methods included: census of nesting for common bird species; census of nesting for raptors and other larger species; census of nesting for nocturnal birds (owl nesting census); and research on flight activity at observation points (research at OT). The field setup of this monitoring cycle is shown in Figure 40. This arrangement of monitoring allowed for a complete overview of the population numbers of the entire bird fauna of the area, the function of the site's habitat for bird fauna, as well as the quantification of flight activity in the wider area, thereby providing a reliable assessment of the potential impacts of the planned solar power plant on the birdlife.



Slika 40. Elementi prostorne postavke monitoringa ptica.

Legenda: Tačke cenzusa gnežđenja (svetloplave tačke); pozicije osmatračkih tačaka (crvene tačke) i pripadajuće područje istraživanja definisano ukupnim vizuelnim obuhvatom (uokvireno crveno); lokacija solarne elektrane (uokvireno belo i žuto), PRP/TS (narandžasto) i dalekovod (zelene linije)

Figure 40. Elements of the Spatial Setup for Bird Monitoring

Legend: Nesting census points (light blue dots); positions of observation points (red dots) and the corresponding research area defined by the total visual coverage (bordered in red); location of the solar power plant (bordered in white and yellow), PRP/TS (orange), and power lines (green lines)

Lista vrsta ornitofaune, na osnovu svih raspoloživih podataka, prikazana je u tabeli 10, koja daje pregled dostupnih podataka i ocenu ekološkog statusa, i tabeli 11, u kojoj se daje pregled statusa zaštite i ugroženosti (potencijalno) prisutnih vrsta. Ovi rezultati i analize smatraju se preliminarnim jer su izrađene na osnovu dosadašnjih istraživanja, tj. pre kompletiranja celokupnog predviđenog ciklusa sistematskog monitoringa. Ipak, očekuju se samo manje izmene, koje će se uglavnom odnositi na utvrđivanje ekološkog statusa onih vrsta, za koje to nije bilo moguće na osnovu raspoloživih podataka, odnosno eventualno dodatno preciziranje za ostale vrste.

The list of bird species, based on all available data, is shown in Table 10, which provides an overview of the available data and an assessment of the ecological status, and in Table 11, which reviews the conservation status and vulnerability of the (potentially) present species. These results and analyses are considered preliminary as they are based on research conducted to date, i.e., before the completion of the entire planned cycle of systematic monitoring. However, only minor changes are expected, which will mostly pertain to determining the ecological status of those species for which it was not possible based on available data, or possibly further refinement for other species.

Tabela 10. Ekološki status vrsta ptica (potencijalno) prisutnih na lokaciji solarne elektrane Brebeks i u neposrednoj okolini, s pregledom nalaza

Table 10. Ecological Status of Bird Species (Potentially) Present at the "Brebex" Solar Power Plant Site and in the Immediate Vicinity with a Review of Findings

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
1	Coturnix coturnix / Common Quail / Prepelica	+	R	U	G,M	G,I,O	
2	Phasianus colchicus / Common Pheasant / Fazan	+	R	U-V	R	G,I,O	
3	Perdix perdix / Grey Partridge / Jarebica	+	e/(R)*	z-n/ (n-U)*	R	(G)*,I,O,p	*DV zone
4	Anas platyrhynchos / Mallard / Gluvara	+	i/(R)*	(n)*	R	(G,I)*,p	*Lipinsko Lake
5	Anas crecca / Common Teal / Krdža	+	i*	(n)*	M,Z	I,O,p	*Lipinsko Lake
6	Columba livia f. domestica / Domestic Pigeon / Domaći golub	+	R	U-(V)	R	(G),I,p	
7	Columba palumbus / Common Wood Pigeon / Golub grivnaš	+	R	U-(V)	R	G,I,p	
8	Streptopelia turtur / European Turtle Dove / Grlica	+	R	U	G,M	G,I,p	
9	Streptopelia decaocto / Eurasian Collared Dove / Gugutka	+	R	n/ (U)*	R	G,I,O,p	*DV zone
10	Caprimulgus europaeus / European Nightjar / Leganj	+	i	z-n	M	I,O,p	
11	Apus apus / Common Swift / Crna čiopa	+	P/R*	n-(U)*	G,M	I,p	*migrating
12	Cuculus canorus / Common Cuckoo / Obična kukavica	+	R	U	G,(M)	G,I,O,p	
13	Ardea cinerea / Grey Heron / Siva čaplja	+	R	n	R	I*,T,p	*Lipinsko Lake
14	Larus michahellis / Yellow-legged Gull / Morski galeb	+	e	n-U	R	I?,p	
15	Otus scops / European Scops Owl / Ćuk	+	i-e/ (R)*	n	G,M	(G,I)*,I?,p	*surroundings

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
16	Asio otus / Long-eared Owl / Utina	+	i-e/ (R)*	n	R	(G,I)*,I?,p	*surroundings
17	Pernis apivorus / European Honey Buzzard / Osičar	+	i	z-(n)	M	I?,p	
18	Circaetus gallicus / Short-toed Snake Eagle / Zmijar	+	i	z-(n)	M	I?,p	
19	Circus aeruginosus / Western Marsh Harrier / Eja močvarica	+	i-e/R*	z-(n)	M,(G)	I,p	*migrating
20	Circus cyaneus / Northern Harrier / Poljska eja	o	e-P	z	Z,(M)	I,p	
21	Circus pygargus / Montagu's Harrier / Eja livadarka	?	i	z	M	p	
22	Accipiter nisus / Eurasian Sparrowhawk / Kobac	+	(i-e)*	(z)*	R	(G),I,p	*DV zone
23	Accipiter gentilis / Northern Goshawk / Jastreb	?	i-e	z	Z,(M)	I,p	
24	Milvus migrans / Black Kite / Crna lunja	?	i	z	M	p	
25	Buteo buteo / Common Buzzard / Mišar	+	R	n-(U)	R	G,I,O,p	
26	Buteo rufinus / Long-legged Buzzard / Riđi mišar	+	i-e	z	G,M	[G],p	
27	Upupa epops / Eurasian Hoopoe / Pupavac	+	P-R	n	G,M	[G],G?,I,O,p	
28	Merops apiaster / European Bee-eater / Pčelarica	+	i-e/ (R)*	U	G,M	(G)*,I,O,p	*surroundings
29	Jynx torquilla / Eurasian Wryneck / Vijoglava	+	i-e/ (R)*	n-U	G,M	(G,I,O)*,p	*DV zone
30	Picus viridis / European Green Woodpecker / Zelena žuna	+	i-e/ (R)*	n-U	R	(G,I,O)*,p	*DV zone

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
31	Dryobates minor / Lesser Spotted Woodpecker / Mali detlić	+	i/(R)*	n	R	(G,I,O)*,p	*DV zone
32	Dendrocoptes medius / Middle Spotted Woodpecker / Srednji detlić	+	R	n-U	R	G,I,O	
33	Dendrocopos syriacus / Syrian Woodpecker / Seoski detlić	+	R	n	R	(G?),G?,I,O,p	
34	Dendrocopos major / Great Spotted Woodpecker / Veliki detlić	+	i-e/ (R)*	n-U	R	(G,I,O)*,p	*DV zone
35	Falco tinnunculus / Common Kestrel / Vetruška	+	R	n-(U)	R	G,I,O,p	
36	Falco subbuteo / Eurasian Hobby / Lastavičar	+	R	z-n	G,M	(G),I,O,p	
37	Falco peregrinus / Peregrine Falcon / Sivi soko	?	i	z	M,Z	p	
38	Lanius collurio / Red-backed Shrike / Rusi svračak	+	R	V	G,(M)	G,I,O,p	
39	Lanius minor / Lesser Grey Shrike / Sivi svračak	+	e-P/ (R)*	z/(n)*	G,M	(G)*,I,O,p	*surroundings
40	Lanius excubitor / Great Grey Shrike / Veliki svračak	?	i-e	z	Z,(M)	I,O,p	
41	Lanius senator / Woodchat Shrike / Crvenoglavi svračak	?	i	z	M	p	
42	Oriolus oriolus / Eurasian Golden Oriole / Vuga	+	R	U-(V)	G,M	G,I,O,p	
43	Garrulus glandarius / Eurasian Jay / Sojka	+	R	U-(V)	G,M	G,I,O	
44	Pica pica / Eurasian Magpie / Svraka	+	R	U-(V)	G,M	G,I,O	
45	Coloeus monedula / Western Jackdaw / Čavka	+	i/(P)*	n	R	(G),I*,O*,p	*DV zone
46	Corvus frugilegus / Rook / Gačac	+	i/(P)*	n	R	[G?],I*,p	*DV zone

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
47	Corvus corax / Common Raven / Gavran	+	R	U	R	(G),I,O,p	
48	Corvus cornix / Hooded Crow / Vrana	+	R	U-(V)	R	G,I,O,p	
49	Poecile palustris / Marsh Tit / Siva senica	+	R	U	R	G,I,O	
50	Poecile lugubris / Sombre Tit / Senica šljivarka	+	R	n	R	G,I,O	
51	Parus major / Great Tit / Velika senica	+	R	U-V	R	G,I,O	
52	Cyanistes caeruleus / Eurasian Blue Tit / Plava senica	+	R	U-(V)	R	G,I,O	
53	Riparia riparia / Sand Martin / Bregunica	+	R	U	M,(G)	p	
54	Hirundo rustica / Barn Swallow / Seoska lasta	+	R	U-V	G,M	G,I,O,p	
55	Cecropis daurica / Red-rumped Swallow / Daurska lasta	+	i-e/R*	n	M,(G)	I,p	*migrating
56	Delichon urbicum / Common House Martin / Gradska lasta	+	R	n-U	M	I?,p	
57	Aegithalos caudatus / Long-tailed Tit / Dugorepa senica	+	R	U-V	R	G,I,O	
58	Galerida cristata / Crested Lark / Ćubasta ševa	?	i-e	z-n	Z	I?,O?,p	
59	Lullula arborea / Wood Lark / Šumska ševa	+	R	U-V	G,M	G,I,O,	
60	Alauda arvensis / Eurasian Skylark / Poljska ševa	+	i-e/ (R)*	(U)*	G,M	(G,I,O)*,p	*DV zone
61	Acrocephalus schoenobaenus / Sedge Warbler / Trstenjak rogožar	+	i/(R)*	z-n/ (n-U)*	M	(G,I)*,p	*Lipinsko Lake
62	Acrocephalus palustris / Marsh Warbler / Trstenjak mlakar	o	i-e	z	M	I?,p	

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
63	Acrocephalus arundinaceus / Great Reed Warbler / Veliki trstenjak	+	i/(R)*	z/(n)*	R	(G,I)*,p	*Lipinsko Lake
64	Hippolais icterina / Icterine Warbler / Žuti voljić	+	i-e	z	M	I?,p	
65	Phylloscopus trochilus / Willow Warbler / Brezov zviždak	o	e	n	M	I,p	
66	Phylloscopus collybita / Common Chiffchaff / Obični zviždak	+	R	U-V	G,M	G,I,O,p	
67	Phylloscopus sibilatrix / Wood Warbler / Šumski zviždak	+	P	n-(U)	M	I,p	
68	Sylvia atricapilla / Eurasian Blackcap / Crnoglava grmuša	+	R	U-V	G,M	G,I,O	
69	Sylvia borin / Garden Warbler / Siva grmuša	+	i-e	z-n	M	I?,p	
70	Curruca communis / Common Whitethroat / Obična grmuša	+	R	V	G,M	G,I,O	
71	Curruca curruca / Lesser Whitethroat / Grmuša čavrljanka	+	R	U-V	G,M	G,I,O	
72	Curruca ni soria / Barred Warbler / Pirgasta grmuša	+	R	n	G,M	G,I,O	
73	Regulus regulus / Goldcrest / Kraljić	o	i-e	z-n	Z,(M)	I,p	
74	Regulus ignicapilla / Common Firecrest / Vatroglavi kraljić	o	i-e	z-n	Z,(M)	I,p	
75	Troglodytes troglodytes / Eurasian Wren / Carić	+	R	n	R	G,I,O	
76	Sitta europaea / Eurasian Nuthatch / Brgljez	+	R	n	R	G,I,O	

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
77	Certhia familiaris / Eurasian Treecreeper / Kratkokljuni puzić	?	i-e	z-n	M,Z	I?,p	
78	Certhia brachydactyla / Short-toed Treecreeper / Dugokljuni puzić	+	R	n	R	G,I,O	
79	Sturnus vulgaris / Common Starling / Čvorak	+	R	U-V		G,I,O	
80	Turdus merula / Common Blackbird / Obični kos	+	R	V	R	G,I,O	
81	Turdus pilaris / Fieldfare / Drozd borovnjak	o	P	z-U	Z,(M)	I?,p	
82	Turdus philomelos / Song Thrush / Drozd pevač	+	R	n-U	G,M,	G,I,O	
83	Turdus viscivorus / Mistle Thrush / Drozd imelaš	+	e-P	n-U	Z,(M)	I,O,p	
84	Erithacus rubecula / European Robin / Crvendać	+	R	U	R	G,I,O	
85	Luscinia megarhynchos / Common Nightingale / Mali slavuj	+	R	V	G,M	G,I,O	
86	Phoenicurus ochruros / Black Redstart / Crna crvenrepka	+	R	n	G,M	G,I,O	
87	Phoenicurus phoenicurus / Common Redstart / Obična crvenrepka	+	R	n	G,M	G,I,O	
88	Saxicola rubetra / Whinchat / Obična travarka	+	R	U	G,M	G,I,O	
89	Saxicola rubicola / European Stonechat / Crnoglava travarka	+	R	n-(U)	G,M	G,I,O	
90	Oenanthe oenanthe / Northern Wheatear / Obična beloguza	?	i-e	z-n	M	I?,O?,p	
91	Muscicapa striata / Spotted Flycatcher / Siva muharica	+	P-R	z-n	M	I?,O?,p	

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
92	Ficedula hypoleuca / European Pied Flycatcher / Crnovrata muharica	?	i	z-n	M	I?,O?,p	
93	Ficedula albicollis / Collared Flycatcher / Belovrata muharica	?	i	z-n	M,(G)	I?,O?,p	
94	Ficedula parva / Red-breasted Flycatcher / Mala muharica	?	i	z-n	M,(G)	I?,O?,p	
95	Passer domesticus / House Sparrow / Vrabac pokućar	+	R	U-(V)	R	G,I,O	
96	Passer montanus / Eurasian Tree Sparrow / Poljski vrabac	+	R	U-(V)	R	G,I,O	
97	Motacilla alba / White Wagtail / Bela pliska	+	R	n-(U)	G,M	G,I,O	
98	Motacilla flava / Yellow Wagtail / Žuta pliska	+	R	n-(U)	G,M	G,I,O	
99	Motacilla cinerea / Grey Wagtail / Potočna pliska	?	i	z	M	I?,O?,p	
100	Anthus campestris / Tawny Pipit / Stepska trepteljka	+	i-e	z	G,M	I?,O?,p	
101	Anthus trivialis / Tree Pipit / Šumska trepteljka	+	R	n-(U)	G,M	G,I,O	
102	Anthus pratensis / Meadow Pipit / Livadska trepteljka	o	i-e	z-n	M,(Z)	I?,O?,p	
103	Anthus spinoletta / Water Pipit / Planinska trepteljka	o	i-e	z-n	M,(Z)	I?,O?,p	
104	Fringilla coelebs / Chaffinch / Zeba	+	R	U-V	R	G,I,O	
105	Fringilla montifringilla / Brambling / Severna zeba	o	P-R	n-U	Z,(M)	I?,O?,p	
106	Serinus serinus / European Serin / Žutarica	?	i-e	z-n	M,(Z)	I?,O?,p	
107	Chloris chloris / European Greenfinch / Zelentarka	+	R	U-V	R	G,I,O	
108	Spinus spinus / Eurasian Siskin / Čižak	o	e-P	n-U	Z,(M)	I,O,p	

Br. / No.	Naziv vrste / Species Name	Nalazi / Findings	Ekološki status / Environmental status				
			Prisustvo / Presence	Brojnost / Abundance	Sezonalnost / Seasonality	Funkcija staništa / Habitat function	Komentar / Comment
109	Carduelis carduelis / European Goldfinch / Češljugar	+	R	U-V	R	G,I,O	
110	Linaria cannabina / Common Linnet / Konopljarka	+	R	U	R	G,I,O	
111	Pyrrhula pyrrhula / Eurasian Bullfinch / Zimovka	o	e-P	n-U	Z,(M)	I,O,p	
112	Coccothraustes coccothraustes / Hawfinch / Batokljun	+	R	U-V/ (n-U)*	R	G,I,O	*wintering
113	Emberiza calandra / Corn Bunting / Velika strnadica	+	R	V	G,M	G,I,O	
114	Emberiza citrinella / Yellowhammer / Strnadica žutovoljka	+	R	U-(V)	R	G,I,O	
115	Emberiza cirlus / Cirl Bunting / Crnogrla strnadica	+	i/(R)*	z/ (n-U)*	G,M	(G,I,O)*,p	*DV zone
116	Emberiza cia / Rock Bunting / Strnadica kamenjarka	?	i-e	z-n	R	I?,O?,p	
117	Emberiza hortulana / Ortolan Bunting / Vinogradska strnadica	+	R	U-(V)	G,M	G,I,O	

Legenda i napomene:
Nalazi: + – potvrđeno (ovim monitoringom za potrebe SE Brebeks), o – očekivano, ? – moguće ali neizvesno;
Ekološki status: prisustvo: R – redovno, P – povremeno, e – retko, i – iznimno, () – mestimično; brojnost: V – visoka, U – umerena, N – niska, z – zanemarljiva, () – povremeno odnosno mestimično; sezonalnost: G – gnezdeća, M – migratorna, Z – zimujuća, R – rezidentna, n/d – nedefinisana, () – retko, [] – u široj okolini; funkcija staništa: G – gnežđenje, I – ishrana, O – odmaranje, T – dnevna tranzicija, p – samo u prolazu, ? – verovatno, () – u neposrednoj okolini, [] – u široj okolini.

Legend and Notes:
Findings: + - confirmed (by this monitoring for the needs of SE "Brebex"), o - expected, ? - possible, but uncertain;
Ecological status: presence: R - regular, P - occasional, e - rare, i - exceptional, () - sporadic;
Abundance: V - high, U - moderate, N - low, z - negligible, () - occasional and/or sporadic;
Seasonality: G - breeding, M - migratory, Z - wintering, R - resident, n/d - undefined, () - rare, [] - in the wider vicinity;
Habitat function: G - nesting, I - feeding, O - resting, T - daily transition, p - passage only, ? - probable, () - in the immediate vicinity, [] - in the wider vicinity.

Ukupno 117 vrsta ptica zabeleženo je ili se smatra (potencijalno) prisutnim na lokaciji planirane solarne elektrane i u neposrednoj okolini. Tokom monitoringa zabeleženo je ukupno 89 vrsta, dok se prisustvo još 12 vrsta smatra očekivanim a 14 mogućim ali ne i izvesnim. (Potencijalno) prisutnih vrsta ima 115 i one čine oko 32% faune ptica Srbije, pa se, na osnovu specijskog diverziteta fauna ptica na području solarne elektrane Brebeks može okarakterisati kao umereno siromašna.

Za vrste koje su zabeležene ili se njihovo prisustvo smatra očekivanim ili mogućim bilo je moguće (preliminarno) utvrđivanje ekološkog statusa (što je prikazano u tabeli 10). Velika većina svih ovih vrsta prisutna je u malom broju i gnezdarice su predmetnog područja.

Iako se ukupan broj od 117 vrsta ptica može okarakterisati kao relativno značajan s faunističkog aspekta, u kvantitativnom smislu broj zabeleženih jedinki relativno je mali.

Većinu faune lokacije solarne elektrane čine rezidentne ili gnezdeće populacije koje se gnezde odnosno hrane na lokaciji odnosno u neposrednoj okolini, pa lokacija ima izvesnu važnost za ove populacije, uključujući i IBA populaciju rusog svračka (*Lanius collurio*). Najbrojnije su gnezdeće populacije vrsta karakterističnih za mozaik žbunastih i travnih staništa, uglavnom malih pevačica (*Passeriformes*). Lokacija ima minimalnu važnost za populacije na seobi i zimovanju.

A total of 117 bird species has been recorded or is considered (potentially) present at the site of the planned “Brebex” solar power plant and its immediate surroundings. During monitoring, a total of 89 species were recorded, while the presence of an additional 12 species is considered expected, and 14 possible but not certain. The 115 (potentially) present species constitute about 32% of the bird fauna of Serbia, and based on species diversity, the bird fauna at the “Brebex” solar power plant can be characterized as moderately poor.

For the species that were recorded or whose presence is considered expected or possible, it was possible to (preliminarily) determine their ecological status (as shown in Table 10). The vast majority of all these species are present in small numbers and are nesting in the subject area.

Although the total number of 117 bird species can be characterized as relatively significant from a faunistic perspective, in quantitative terms, the number of recorded individuals is relatively small.

Most of the fauna at the solar power plant site consists of resident or breeding populations that nest and/or feed at the site and/or in the immediate vicinity, thus the site holds certain importance for these populations, including the IBA population of the Red-backed Shrike (Lanius collurio). The most numerous are breeding populations of species typical of the mosaic of shrubby and grassy habitats, mostly small passerines (Passeriformes). The site has minimal importance for populations on migration and wintering.

Tabela 11. Status zaštite i ugroženosti vrsta ptica (potencijalno) prisutnih na lokaciji solarne elektrane Brebeks i u neposrednoj okolini

Table 11. Conservation Status and Vulnerability of Bird Species (Potentially) Present at the "Brebex" Solar Power Plant Site and in Its Immediate Vicinity

Br. / No.	Naziv vrste / Species name	Konvencija/ Convention (dodatak / addendum)		EU Direkt. ptice / birds (prilog / addendum)	SRB zakon / SRB law (SZ/Z)	IUCN			Ornitofauna / Bird Life SPEC
		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
1	Coturnix coturnix / Common Quail / Prepelica	III	II	II/B	Z	LC	NT	LC	3
2	Phasianus colchicus / Common Pheasant / Fazan	III		II/A+III/A	Z	LC	LC	n/a	
3	Perdix perdix / Grey Partridge / Jarebica	III		II/A+III/A	Z	LC	LC	VU	2
4	Anas platyrhynchos / Mallard / Gluvara	III	II	II/A+III/A	Z	LC	LC	LC	
5	Anas crecca / Common Teal / Krdža	III	II	II/A+III/B	Z	LC	LC	LC*	
6	Columba livia f. domestica / Domestic Pigeon / Domaći golub					n/a	n/a	n/a	
7	Columba palumbus / Common Wood Pigeon / Golub grivnaš			II/A+III/A	Z	LC	LC	LC	
8	Streptopelia turtur / European Turtle Dove / Grlica	III	II	II/B	Z	VU	VU	VU	1
9	Streptopelia decaocto / Eurasian Collared Dove / Gugutka	III		II/B	Z	LC	LC	LC	

Br. / No.	Naziv vrste / Species name	Konvencija/ Convention (dodatak / addendum)		EU Direkt. ptice / birds (prilog / addendum)	SRB zakon / SRB law (SZ/Z)	IUCN			Ornitofauna / Bird Life SPEC
		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
10	Caprimulgus europaeus / European Nightjar / Leganj	II		I	SZ	LC	LC	LC	3
11	Apus apus / Common Swift / Crna čiopa	III			SZ	LC	NT	LC	3
12	Cuculus canorus / Common Cuckoo / Obična kukavica	III			SZ	LC	LC	LC	
13	Ardea cinerea / Grey Heron / Siva čaplja	III			Z	LC	LC	LC	
14	Larus michahellis / Yellow-legged Gull / Morski galeb	III				LC	LC	LC*	
15	Otus scops / European Scops Owl / Ćuk	II			SZ	LC	LC	LC	2
16	Asio otus / Long-eared Owl / Utina	II			SZ	LC	LC	LC	
17	Pernis apivorus / European Honey Buzzard / Osičar	II	II	I	SZ	LC	LC	LC*	
18	Circaetus gallicus / Short-toed Snake Eagle / Zmijar	II	II	I	SZ	LC	LC	NT*	
19	Circus aeruginosus / Western Marsh Harrier / Eja močvarica	II	II	I	SZ	LC	LC	LC*	
20	Circus cyaneus / Northern Harrier / Poljska eja	II	II	I	SZ	LC	LC	VU*	3
21	Circus pygargus / Montagu's Harrier / Eja livadarka	II	II	I	SZ	LC	LC	LC*	

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
22	Accipiter nisus / Eurasian Sparrowhawk / Kobac	II	II		SZ	LC	LC	LC	
23	Accipiter gentilis / Northern Goshawk / Jastreb	II	II		Z	LC	LC	LC*	
24	Milvus migrans / Black Kite / Crna lunja	II	II	I	SZ	LC	LC	DD*	3
25	Buteo buteo / Common Buzzard / Mišar	II	II		SZ	LC	LC	LC	
26	Buteo rufinus / Long-legged Buzzard / Riđi mišar	II	II	I	SZ	LC	LC	VU	
27	Upupa epops / Eurasian Hoopoe / Pupavac	II			SZ	LC	LC	LC	
28	Merops apiaster / European Bee-eater / Pčelarica	II	II		SZ	LC	LC	LC	
29	Jynx torquilla / Eurasian Wryneck / Vijoglava	II			SZ	LC	LC	LC	3
30	Picus viridis / European Green Woodpecker / Zelena žuna	II			SZ	LC	LC	LC	
31	Dryobates minor / Lesser Spotted Woodpecker / Mali detlić	II			SZ	LC	LC	LC	
32	Dendrocoptes medius / Middle Spotted Woodpecker / Srednji detlić	II		I	SZ	LC	LC	LC	

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
33	Dendrocopos syriacus / Syrian Woodpecker / Seoski detlić	II		I	SZ	LC	LC	LC	
34	Dendrocopos major / Great Spotted Woodpecker / Veliki detlić	II			SZ	LC	LC	LC	
35	Falco tinnunculus / Common Kestrel / Vetruška	II	II		SZ	LC	LC	LC	3
36	Falco subbuteo / Eurasian Hobby / Lastavičar	II	II		SZ	LC	LC	LC	
37	Falco peregrinus / Peregrine Falcon / Sivi soko	II	II	I	SZ	LC	LC	NT*	
38	Lanius collurio / Red-backed Shrike / Rusi svračak	II		I	SZ	LC	LC	LC	2
39	Lanius minor / Lesser Grey Shrike / Sivi svračak	II	II	I	SZ	LC	LC	LC	2
40	Lanius excubitor / Great Grey Shrike / Veliki svračak	II	II		SZ	LC	LC	LC*	3
41	Lanius senator / Woodchat Shrike / Crvenoglavi svračak	II			SZ	LC	NT	LC	2
42	Oriolus oriolus / Eurasian Golden Oriole / Vuga	II	II		SZ	LC	LC	LC	
43	Garrulus glandarius / Eurasian Jay / Sojka			II/B	Z	LC	LC	LC	
44	Pica pica / Eurasian Magpie / Svraka			II/B	Z	LC	LC	LC	
45	Coloeus monedula / Western Jackdaw / Čavka			II/B	Z	LC	LC	LC	

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
46	Corvus frugilegus / Rook / Gačac			II/B	Z	LC	VU	LC	
47	Corvus corax / Common Raven / Gavran	III			Z	LC	LC	LC	
48	Corvus cornix / Hooded Crow / Vrana			II/B	Z	LC	LC	LC	
49	Poecile palustris / Marsh Tit / Siva senica	II			SZ	LC	LC	LC	
50	Poecile lugubris / Sombre Tit / Senica šljivarka	II			SZ	LC	LC	LC	
51	Parus major / Great Tit / Velika senica	II			SZ	LC	LC	LC	
52	Cyanistes caeruleus / Eurasian Blue Tit / Plava senica	II			SZ	LC	LC	LC	
53	Riparia riparia / Sand Martin / Bregunica	II			SZ	LC	LC	LC*	3
54	Hirundo rustica / Barn Swallow / Seoska lasta	II			SZ	LC	LC	LC	3
55	Cecropis daurica / Red-rumped Swallow / Daurska lasta	II			SZ	LC	LC	LC*	
56	Delichon urbicum / Common House Martin / Gradska lasta	II			SZ	LC	LC	LC*	2
57	Aegithalos caudatus / Long-tailed Tit / Dugorepa senica	II	II		SZ	LC	LC	LC	
58	Galerida cristata / Crested Lark / Ćubasta ševa	III			SZ	LC	LC	LC*	3

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
59	Lullula arborea / Wood Lark / Šumska ševa	III		I	SZ	LC	LC	LC	2
60	Alauda arvensis / Eurasian Skylark / Poljska ševa	III		II/B	SZ	LC	LC	LC	3
61	Acrocephalus schoenobaenus / Sedge Warbler / Trstenjak rogožar	II	II		SZ	LC	LC	LC*	
62	Acrocephalus palustris / Marsh Warbler / Trstenjak mlakar	II	II		SZ	LC	LC	LC*	
63	Acrocephalus arundinaceus / Great Reed Warbler / Veliki trstenjak	II	II		SZ	LC	LC	LC	
64	Hippolais icterina / Icterine Warbler / Žuti voljić	II	II		SZ	LC	LC	LC*	
65	Phylloscopus trochilus / Willow Warbler / Brezov zviždak	II	II		SZ	LC	LC	LC*	3
66	Phylloscopus collybita / Common Chiffchaff / Obični zviždak	II	II		SZ	LC	LC	LC	
67	Phylloscopus sibilatrix / Wood Warbler / Šumski zviždak	II	II		SZ	LC	LC	LC*	
68	Sylvia atricapilla / Eurasian Blackcap / Crnoglava grmuša	II	II		SZ	LC	LC	LC	

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
69	Sylvia borin / Garden Warbler / Siva grmuša	II	II		SZ	LC	LC	LC*	
70	Curruca communis / Common Whitethroat / Obična grmuša	II	II		SZ	LC	LC	LC	
71	Curruca curruca / Lesser Whitethroat / Grmuša čavrljanka	II	II		SZ	LC	LC	LC	
72	Curruca nisoria / Barred Warbler / Pirgasta grmuša	II	II	I	SZ	LC	LC	LC	
73	Regulus regulus / Goldcrest / Kraljić	II	II		SZ	LC	LC	LC*	2
74	Regulus ignicapilla / Common Firecrest / Vatroglavi kraljić	II	II		SZ	LC	LC	LC*	
75	Troglodytes troglodytes / Eurasian Wren / Carić	II			SZ	LC	LC	LC	
76	Sitta europaea / Eurasian Nuthatch / Brgljez	II			SZ	LC	LC	LC	
77	Certhia familiaris / Eurasian Treecreeper / Kratkokljuni puzić	II			SZ	LC	LC	LC*	
78	Certhia brachydactyla / Short-toed Treecreeper / Dugokljuni puzić	II			SZ	LC	LC	LC	
79	Sturnus vulgaris / Common Starling / Čvorak			II/B	Z	LC	LC	LC	3

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
80	Turdus merula / Common Blackbird / Obični kos	III	II	II/B	SZ	LC	LC	LC	
81	Turdus pilaris / Fieldfare / Drozd borovnjak	III	II	II/B	SZ	LC	LC	LC*	
82	Turdus philomelos / Song Thrush / Drozd pevač	III	II	II/B	SZ	LC	LC	LC	
83	Turdus viscivorus / Mistle Thrush / Drozd imelaš	III	II	II/B	SZ	LC	LC	LC*	
84	Erithacus rubecula / European Robin / Crvendać	II	II		SZ	LC	LC	LC	
85	Luscinia megarhynchos / Common Nightingale / Mali slavuj	II	II		SZ	LC	LC	LC	
86	Phoenicurus ochruros / Black Redstart / Crna crvenrepka	II	II		SZ	LC	LC	LC	
87	Phoenicurus phoenicurus / Common Redstart / Obična crvenrepka	II	II		SZ	LC	LC	LC	
88	Saxicola rubetra / Whinchat / Obična travarka	II	II		SZ	LC	LC	LC	2
89	Saxicola rubicola / European Stonechat / Crnoglava travarka	II	II		SZ	LC	LC	LC	
90	Oenanthe oenanthe / Northern Wheatear / Obična beloguza	II	II		SZ	LC	LC	LC*	3

Br. / No.	Naziv vrste / Species name	Konvencija/ Convention (dodatak / addendum)		EU Direkt. ptice / birds (prilog / addendum)	SRB zakon / SRB law (SZ/Z)	IUCN			Ornitofauna / Bird Life SPEC
		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
91	Muscicapa striata / Spotted Flycatcher / Siva muharica	II	II		SZ	LC	LC	LC*	2
92	Ficedula hypoleuca / European Pied Flycatcher / Crnovrata muharica	II	II		SZ	LC	LC	LC*	
93	Ficedula albicollis / Collared Flycatcher / Belovrata muharica	II	II	I	SZ	LC	LC	LC*	
94	Ficedula parva / Red-breasted Flycatcher / Mala muharica	II	II	I	SZ	LC	LC	LC*	
95	Passer domesticus / House Sparrow / Vrabac pokućar				Z	LC	LC	LC	3
96	Passer montanus / Eurasian Tree Sparrow / Poljski vrabac	III			Z	LC	LC	LC	3
97	Motacilla alba / White Wagtail / Bela pliska	II	II		SZ	LC	LC	LC	
98	Motacilla flava / Yellow Wagtail / Žuta pliska	II	II		SZ	LC	LC	LC	3
99	Motacilla cinerea / Grey Wagtail / Potočna pliska	II	II		SZ	LC	LC	LC*	
100	Anthus campestris / Tawny Pipit / Stepska trepteljka	II	II	I	SZ	LC	LC	LC	3
101	Anthus trivialis / Tree Pipit / Šumska trepteljka	II	II		SZ	LC	LC	LC	3
102	Anthus pratensis / Meadow Pipit / Livadska trepteljka	II	II		SZ	NT	NT	LC*	1

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
103	Anthus spinoletta / Water Pipit / Planinska trepteljka	II	II		SZ	LC	LC	LC*	
104	Fringilla coelebs / Chaffinch / Zeba	III			SZ	LC	LC	LC	
105	Fringilla montifringilla / Brambling / Severna zeba	III			SZ	LC	LC	LC*	3
106	Serinus serinus / European Serin / Žutarica	II			SZ	LC	LC	LC*	2
107	Chloris chloris / European Greenfinch / Zelentarka	II			SZ	LC	LC	LC	
108	Spinus spinus / Eurasian Siskin / Čižak	II			SZ	LC	LC	LC*	
109	Carduelis carduelis / European Goldfinch / Češljugar	II			SZ	LC	LC	LC	
110	Linaria cannabina / Common Linnet / Konopljarka	II			SZ	LC	LC	LC*	2
111	Pyrrhula pyrrhula / Eurasian Bullfinch / Zimovka	III			SZ	LC	LC	LC*	
112	Coccothraustes coccothraustes / Hawfinch / Batokljun	II			SZ	LC	LC	LC	
113	Emberiza calandra / Corn Bunting / Velika strnadica	III			SZ	LC	LC	LC	

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		Bern	Bon / Bonn			Globalno / Globally	Evropa / Europe	Srbija / Serbia	
114	Emberiza citrinella / Yellowhammer / Strnadica žutovoljka	II			SZ	LC	LC	LC	2
115	Emberiza cirlus / Cirl Bunting / Crnogrla strnadica	II			SZ	LC	LC	LC	
116	Emberiza cia / Rock Bunting / Strnadica kamenjarka	II			SZ	LC	LC	LC	
117	Emberiza hortulana / Ortolan Bunting / Vinogradska strnadica	III		I	SZ	LC	LC	LC	2

Legenda i napomene:

Konvencija:

Bern – Bernska konvencija o očuvanju evropske divlje flore i faune i prirodnih staništa („Službeni glasnik RS", br. 102 / 2007): Dodatak II ili III; Bon – Bonska konvencija o očuvanju migratornih vrsta divljih životinja („Službeni glasnik RS", br. 102/2007): Dodatak I i II;

EU Direkt. ptice – Direktiva o zaštiti divljih ptica EU (*Official Journal of EU* [2009/147/EC]): Prilog I, II i/ili III;

SRB zakon – Zakon o zaštiti prirode RS („Službeni glasnik RS", br. 36/2009a, 88/2010, 91/2010 – ispravka, 14/2016, 95/2018 – drugi zakon, 71/2021), Pravilnik o proglašenju i zaštiti strogo zaštićenih i zaštićenih divljih vrsta biljaka, životinja i gljiva („Službeni glasnik RS", br. 5/2010, 32/2016, 98/2016): SZ – strogo zaštićena divlja vrsta, Z – zaštićena divlja vrsta;

IUCN – IUCN (2023) kategorije: EN – ugrožena, VU – ranjiva, NT – skoro ugrožena, LC – najmanja briga, DD – nedostatak podataka, NE – nije izvršena evaluacija, n/a – nije podesna, * negnezdeća populacija;

Bird Life SPEC – kategorije konzervacionog značaja *BirdLife International* (2017): *SPEC 1* – evropska vrsta od globalnog konzervacionog značaja, *SPEC 2* – vrsta od evropskog konzervacionog značaja čija je globalna populacija koncentrisana u Evropi, *SPEC 3* – vrsta od evropskog konzervacionog značaja čija globalna populacija nije koncentrisana u Evropi.

Legend and Notes:

Convention:

Bern - Bern Convention on the Conservation of European Wildlife and Natural Habitats ("Official Gazette of RS" No. 102 / 2007): Annex II or III;

Bonn - Bonn Convention on the Conservation of Migratory Species of Wild Animals ("Official Gazette of RS" No. 102 / 2007): Annex I and II;

EU Birds Directive - EU Directive on the Conservation of Wild Birds (Official Journal of EU [2009/147/EC]): Annex I, II and/or III;

SRB zakon - Law on Nature Protection of the Republic of Serbia ("Official Gazette of RS" No. 36/2009a, 88/2010, 91/2010 - correction, 14/2016, 95/2018 – another law, 71/2021), Regulation on the Designation and Protection of Strictly Protected and Protected Wild Species of Plants, Animals, and Fungi ("Official Gazette of RS" No. 5/2010, 32/2016, 98/2016): SZ - strictly protected wild species, Z - protected wild species;

IUCN - IUCN (2023) categories: EN - endangered, VU - vulnerable, NT - near threatened, LC - least concern, DD - data deficient, NE - not evaluated, n/a - not applicable, * non-breeding population;

Bird Life SPEC - BirdLife International conservation significance categories (2017): SPEC 1 - a European species of global conservation concern, SPEC 2 - a species of European conservation concern whose global population is concentrated in Europe, SPEC 3 - a species of European conservation concern whose global population is not concentrated in Europe.

Na globalnom i evropskom nivou ugrožena je jedna od prisutnih vrsta, klasifikovana kao ranjiva (VU). Na globalnom nivou još jedna vrsta klasifikovana je kao skoro ugrožena (NT), a na evropskom nivou još jedna vrsta kao ranjiva (VU) a četiri kao skoro ugrožene (NT). Na nacionalnom nivou ugrožene su 4 vrste, koje su sve klasifikovane kao ranjive (VU), a skoro su ugrožene (NT) 2 vrste. Dve vrste su klasifikovane kao evropske vrste od globalnog konzervacionog značaja, 14 vrsta klasifikovano je kao vrste od evropskog konzervacionog značaja čija je globalna populacija koncentrisana u Evropi i 21 vrsta klasifikovana je kao vrste od evropskog konzervacionog značaja čija globalna populacija nije koncentrisana u Evropi.

Od 8 vrsta na osnovu čijih je gnezdećih/rezidentnih populacija identifikovano IBA područje Gornji visok i Vidlič, čijim granicama je delom obuhvaćena lokacija planirane solarne elektrane, na lokaciji solarne elektrane (i priključnog dalekovoda) i u relevantnoj neposrednoj okolini, utvrđeno je gnežđenje samo rusog svračka (*Lanius collurio*), a pojedinačne jedinke riđeg mišara (*Buteo rufinus*) i zmijara (*Circaetus gallicus*) prisutne su samo iznimno u prolazu. Iscrpna ciljana terenska istraživanja nisu utvrdila prisustvo prdavca (*Crex crex*) na predmetnom području, niti staništa pogodnih za ovu vrstu, dok su sve ostale IBA vrste vezane za (visoko) planinska šumska i stenovita staništa kakvih na predmetnom području nema pa njihovo prisustvo nije ni bilo očekivano.

Globally and in Europe, one of the species present is endangered, classified as Vulnerable (VU). Globally, another species is classified as Near Threatened (NT), and in Europe, another species as Vulnerable (VU) and four as Near Threatened (NT). Nationally, 4 species are endangered, all classified as Vulnerable (VU), and 2 species are Near Threatened (NT). Two species are classified as European species of global conservation significance, 14 species as species of European conservation significance whose global populations are concentrated in Europe, and 21 species as species of European conservation significance whose global populations are not concentrated in Europe.

Of the 8 species whose nesting/resident populations have identified the IBA area Gornji Visok and Vidlič, partly covering the site of the planned solar power plant, nesting has been confirmed only for the Red-backed Shrike (Lanius collurio) at the solar power plant site (and the associated power line) and its relevant immediate vicinity. Individual instances of the Long-legged Buzzard (Buteo rufinus) and the Short-toed Snake Eagle (Circaetus gallicus) are only exceptionally present in passage. Exhaustive targeted field research did not confirm the presence of the Corncrake (Crex crex) in the area, nor habitats suitable for this species, while all other IBA species are linked to (high) mountainous forest and rocky habitats which are absent in the area, so their presence was not expected.

5.2.4. Kvalitet životne sredine

Stanje kvaliteta elemenata životne sredine u opštini Dimitrovgrad rezultat je interakcije dosadašnjeg razvoja i prirodnih determinanti. Kvalitetna životna sredina važan je faktor budućeg razvoja opštine i ogleda se kroz obezbeđivanje zdrave životne sredine za stanovništvo. Očuvanjem zdrave

5.2.4. Environmental Quality

The state of environmental quality in the municipality of Dimitrovgrad is the result of the interaction between past development and natural determinants. A high-quality environment is an important factor for the future development of the municipality and is reflected through the provision of životne sredine, kako na teritoriji opštine Dimitrovgrad, tako i u susednim lokalnim samoupravama, stvaraju se preduslovi i značajni potencijali za razvoj.

Na teritoriji opštine Dimitrovgrad ne sprovodi se kontinuirani monitoring kvaliteta životne sredine po svim njegovim elementima, ali se na osnovu interpolacije podataka može konstatovati da su postojeće aktivnosti i nedovoljna komunalna opremljenost na teritoriji opštine uticale na kvalitet životne sredine i izazvale lokalne i šire ekološke probleme. Jedan od najvećih ekoloških problema svakako je problem s otpadom, ispuštanje neprečišćenih otpadnih voda iz domaćinstava i privrede, negativni uticaji saobraćaja duž koridora saobraćajnica, kao i negativni uticaji upotrebe fosilnih goriva u energetske svrhe u domaćinstvima i privredi.

Na samoj lokaciji planirane solarne elektrane Brebeks ne vrši se monitoring životne sredine, tako da se ocena glavnih elemenata i pokazatelja stanja životne sredine izvodi posredno, na osnovu raspoloživih podataka s područja opštine Dimitrovgrad, odnosno na osnovu raspoložive planske i druge dokumentacije, na osnovu koje se na osnovu interpolacije podataka mogu izvesti zaključci o kvalitetu osnovnih činilaca životne sredine.

Kvalitet vazduha – Uslovljen je klimatskim, geografskim, geomorfološkim karakteristikama, kao i emisijom polutanata iz raznih stalnih ili povremenih izvora. Razvoj, potreba za energijom i energentima, urbanizacija i razvoj saobraćaja uslovili su antropogeni uticaj na elemente životne sredine, odnosno kvalitet vazduha. Osnovni činioci koji utiču na kvalitet vazduha jesu tehnološki procesi i operacije privrede,

a healthy environment for the population. By preserving a healthy environment, both in the territory of the municipality of Dimitrovgrad and in neighboring local administrations, conditions and significant potentials for development are created.

In the territory of the municipality of Dimitrovgrad, continuous monitoring of environmental quality across all its elements is not conducted, but based on data interpolation, it can be observed that existing activities and insufficient municipal infrastructure in the territory have impacted the environmental quality and caused local and wider ecological problems. One of the biggest ecological problems is undoubtedly the issue of waste, the discharge of untreated wastewater from households and businesses, negative impacts from traffic along traffic corridor routes, and negative impacts from the use of fossil fuels for energy purposes in households and businesses.

At the site of the planned "Brebex" solar power plant, environmental monitoring is not conducted, so the assessment of the main elements and indicators of the environmental state is carried out indirectly, based on available data from the area of the municipality of Dimitrovgrad, and based on available planning and other documentation, from which, based on data interpolation, conclusions about the quality of basic environmental factors can be drawn.

Air Quality - is conditioned by climatic, geographical, geomorphological characteristics, as well as emissions of pollutants from various permanent or temporary sources. Development, energy needs, urbanization, and transportation development have led to anthropogenic impacts on environmental elements, sagorevanje benzina, dizel goriva i drugog pogonskog goriva i transformisanje hemijske energije goriva u mehaničku i toplotnu. Energetska postrojenja za potrebe privrede i individualne kotlarnice u kojima se vrši sagorevanje fosilnih ili čvrstih goriva dovode do emitovanja zagađujućih supstanci. Hemijski sastav tipičnih zagađujućih supstanci uslovljen je elementarnim sastavom fosilnih goriva. Istovremeno, saobraćaj predstavlja treći segment koji utiče na kvalitet saobraćaja. Emituju se ugljenikovi oksidi, azotovi oksidi, sumporni oksidi, kao i teški metali (olovo), ugljovodonici, dim i čađ. Aeropolutanti potiču iz: (1) industrije (SO_2, merkaptan, neprijatni mirisi i drugi polutanti), (2) kotlarnica centralnog grejanja u gradu (fosilna goriva), i (3) saobraćaja (NO, NO_2, CO_2, ugljovodonici, Pb, čestice čađi, prašina i dr.). Aerozagađenja iz domaćinstava i saobraćaja na području opštine posledica su sagorevanja čvrstih i tečnih energenata i pogonskih fosilnih goriva – naftnih derivata, uglja i sl., čiji su produkt sledeće supstance: čađ, pepeo, dim, SO_2, NH jedinjenja, CO_2, Pb, aldehidi, čestice i dr. Dominantni izvori zagađenja vazduha jesu saobraćaj i privreda. Pored saobraćaja i privrede, domaćinstva, odnosno naselja, predstavljaju izvor potencijalnog zagađivanja usled komunalne neopremljenosti i neorganizovanosti (prikupljanje čvrstog otpada, odvođenje otpadnih voda, nerešen sistem daljinskog grejanja u urbanom centru i sl.). Na planskom području konstatuje se da je vazduh relativno nezagađen zbog nedostatka ozbiljnih industrijskih zagađivača. Monitoring kvaliteta vazduha se ne vrši. Povremeno se mogu javiti povećanja koncentracija nekih zagađujućih materija u vazduhu u blizini državnih puteva I i II reda i železničke stanice, kao i u pojedinim naseljima zbog loženja u zimskom periodu.

specifically air quality. The main factors affecting air quality include: technological processes and operations of the economy, combustion of gasoline, diesel, and other fuels, and the transformation of chemical energy from fuels into mechanical and thermal energy. Energy plants for industrial needs and individual boilers burning fossil or solid fuels lead to the emission of pollutants. The chemical composition of typical pollutants is determined by the elemental composition of fossil fuels. Meanwhile, traffic represents a third segment affecting air quality. Emissions include carbon oxides, nitrogen oxides, sulfur oxides, as well as heavy metals (lead), hydrocarbons, smoke, and soot. Air pollutants originate from: (1) industry (SO_2, mercaptans, unpleasant odors, and other pollutants); (2) central heating boilers in the city (fossil fuels), and (3) traffic (NO, NO_2, CO_2, hydrocarbons, Pb, particulate soot, dust, etc.). Air pollution from households and traffic in the municipality results from the combustion of solid and liquid energy sources and fossil fuels—petroleum derivatives, coal, etc., including substances such as soot, ash, smoke, SO_2, NH compounds, CO_2, Pb, aldehydes, particles, etc. The dominant sources of air pollution are traffic and industry. Besides traffic and industry, households or settlements represent a potential source of pollution due to lack of municipal infrastructure and organization (solid waste collection, wastewater disposal, unresolved central heating systems in the urban center, etc.). The planning area is noted to have relatively unpolluted air due to the absence of serious industrial pollutants. Air quality monitoring is not conducted. There may occasionally be increases in concentrations of some pollutants in the air near state roads of I and II order and the railway station, as well as in some settlements due to heating in

Duž lokalnih puteva bez kolovoza javlja se povećana zaprašenost u toku sušnih letnjih meseci.

Kvalitet voda – U izvore zagađenja voda spadaju nekontrolisano ispuštanje otpadnih voda (industrijske/tehnološke, fekalne/kanalizacione, atmosferske) i nekontrolisano odlaganje otpada pored puteva, na poljoprivrednom zemljištu, u blizini rečnih tokova, u priobaljima, čak i u rečnim koritima. Veliki problem predstavlja zagađivanje podzemnih voda zbog korišćenja nesanitarnih septičkih jama, koje se koriste u najvećem broju naselja. Podzemne vode se zagađuju pesticidima i herbicidima iz poljoprivrede, procednim deponijskim filtratom i zahvatanjem podzemnih voda kaptiranjem izvora/vrela ili bušenim/kopanim bunarima od strane lokalnog stanovništva. Kvalitet voda reke Jerme na lokalitetu Trnski Odorovci prati se u okviru redovnog monitoringa koji sprovodi Agencija za zaštitu životne sredine u okviru redovnog godišnjeg monitoringa. Podaci pokazuju da izmereni biološki, mikrobiološki, fizički i hemijski parametri odgovaraju I–II klasi kvaliteta vode prema Uredbi o graničnim vrednostima zagađujućih materija u površinskim i podzemnim vodama i sedimentu i rokovima za njihovo dostizanje („Službeni glasnik RS”, broj 50/2012).

Kvalitet zemljišta – Ekološki pritisak na zemljište prisutno je u zonama koncentracije stanovništva i privrednih aktivnosti. Sa stanovišta zaštite kvaliteta zemljišta značajan je problem trajnog gubitka usled prenamene zemljišta u građevinsko. Vrlo značajno je da je na teritoriji opštine prisutno zagađivanje zemljišta, koje nastaje usled nekontrolisane primene mineralnih đubriva i hemijskih sredstava zaštite. Indirektno zagađivanje zemljišta nastaje usled korišćenja nesanitarnih septičkih jama, koje se koriste u najvećem broju naselja. Deponije (smetlišta) otpada koje se nalaze na teritoriji opštine nisu

the winter period. Along local unpaved roads, increased dustiness occurs during dry summer months.

Water Quality - Sources of water pollution include: uncontrolled discharge of wastewater (industrial/technological, faecal/sewage, stormwater), uncontrolled waste disposal beside roads, on agricultural land, near river courses, riverbanks, and even within river beds. A significant issue is the pollution of groundwater due to the use of unsanitary septic tanks, which are prevalent in most settlements. Groundwater is polluted by pesticides and herbicides from agriculture, leachate from landfills, and the extraction of groundwater through capturing springs or drilling/dug wells by the local population. The water quality of the Jerma River at the Trnski Odorovci site is monitored as part of regular monitoring conducted by the Environmental Protection Agency within the framework of annual monitoring. Data show that the measured biological, microbiological, physical, and chemical parameters meet Class I-II water quality standards according to the Regulation on limit values of pollutants in surface and groundwater and sediment and deadlines for their achievement (“Official Gazette of RS”, number 50/2012).

Soil Quality - Ecological pressure on soil is present in areas of population concentration and economic activities. From the standpoint of protecting soil quality, the permanent loss due to land repurposing into construction sites is significant. It is very important that there is pollution of the soil in the municipality area due to uncontrolled use of mineral fertilizers and chemical pesticides. Indirect soil pollution occurs because of the use of unsanitary septic tanks, which are common in most settlements. Landfills (waste dumps) located within the municipality uređene po propisima, zbog čega dolazi do zagađivanja zemljišta i podzemnih voda usled procеđivanja deponijskog filtrata i raznošenja smeća po okolnom zemljištu. Odvijanje saobraćaja takođe dovodi do zagađenja zemljišta u neposrednoj blizini saobraćajnica usled povećanog sadržaja olova na putnom zemljištu i u blizini saobraćajnica. Podataka o obimu zagađivanja zemljišta nema, jer se na prostoru opštine ne vrše merenja i istraživanja kvaliteta zemljišta.

Buka – Ne vrši se sistematski monitoring buke. Potencijalni izvori buke vezani su za odvijanje intenzivnog saobraćaja, a posebno su ugrožena naselja Beleš i Dimitrovgrad pored koridora autoputa, a naselje Dimitrovgrad i zbog prolaska magistralne železničke pruge.

are not regulated, resulting in soil and groundwater pollution due to leachate percolation and the scattering of waste around the surrounding land. Traffic also leads to soil pollution near roadways due to increased levels of lead in the road soil and near roadways. There is no data on the extent of soil pollution because no measurements or research on soil quality are conducted in the municipality area.

Noise - Systematic noise monitoring is not conducted. Potential sources of noise are related to intense traffic, particularly affecting the settlements of Beleš and Dimitrovgrad beside the motorway corridor, and Dimitrovgrad also due to the passage of the main railway line.

5.2.5. Kulturna dobra

Na širem prostoru postoje nevalorizovani podaci o sledećim arheološkim lokalitetima koji uživaju prethodnu zaštitu na osnovu Zakona o kulturnom nasleđu:

1. Arheološki lokalitet Bačevsko polje, Bačevo, rimsko naselje, Mutatio Ballasantra,
2. Arheološki lokalitet Potok, Bačevo, novovekovni vodovod – vodovod,
3. Arheološki lokalitet Lug, Bačevo, antička građevina,
4. Arheološki lokalitet T'sk, Bačevo, praistorijsko naselje (eneolit),
5. Arheološki lokalitet Crkvište Sv. Đorđa, Bačevo, crkvište (16–17. vek),
6. Arheološki lokalitet Golemi Kamik, Bačevo, dve kule,
7. Arheološki lokalitet Kndina bara, Gradinje, ostaci rimskog puta (Via militaris),
8. Arheološki lokalitet Crkva Sv. Dimitrija, Brebevnica, ostaci crkve.

5.2.5. Cultural goods

In the wider area, there are unassessed data on the following archaeological sites that are preliminarily protected under the Law on Cultural Heritage:

1. Archaeological site Bačevsko Polje, Bačevo, Roman settlement, mutatio Ballasantra,
2. Archaeological site Potok, Bačevo, early modern aqueduct - aqueduct,
3. Archaeological site Lug, Bačevo, ancient building,
4. Archaeological site T'sk, Bačevo, prehistoric settlement (Chalcolithic),
5. Archaeological site Crkviše Sv. Đorđa, Bačevo, churchyard (16th-17th century),
6. Archaeological site Golemi Kamik, Bačevo, two towers,
7. Archaeological site Kndina Bara, Gradinje, remains of a Roman road (via militaris-a),
8. Archaeological site Church of St. Dimitrije, Brebevnica, church remains.

U skladu sa uslovima Zavoda za zaštitu spomenika kulture Niš, konstatovano je da na prostoru u okviru lokacija planiranih za izgradnju solarne elektrane Brebeks nije izvršena sistematska prospekcija i valorizacija nepokretnog kulturnog nasleđa, arheološkog nasleđa i ratnih memorijala, te da ne postoje utvrđeni podaci o istim. Za potrebe izrade tehničke dokumentacije i određivanja tačnih pozicija za postavljanje objekata solarne elektrane biće dovršena započeta arheološka istraživanja na lokaciji planirane solarne elektrane.

According to the Institute for the Protection of Cultural Monuments, Niš, it has been established that the area within the locations planned for the construction of the "Brebex" solar power plant has not undergone systematic prospecting and assessment of immovable cultural heritage, archaeological heritage, and war memorials, and that there are no established data on the same. For the purposes of preparing technical documentation and determining the exact positions for placing solar power plant facilities, the started archaeological investigations at the planned solar power plant location will be completed.

5.2.6. Antropogene karakteristike prostora

Najveći deo analiziranog područja sa zonama uticaja namenjen je poljoprivredi. Radi se o tzv. zaparloženim njivama koje se ne koriste u poljoprivredne svrhe godinama unazad.

Manji deo prostora obuhvataju saobraćajne površine i to opštinski put za naseljeno mesto Bačevo i mreža lokalnih nekategorisanih puteva, kao i delovi zemljišta pod šumama.

Prostor obuhvaćen planskom dokumentacijom i SPU obuhvata i opštinski put za naseljeno mesto Bačevo i mrežu lokalnih nekategorisanih puteva koji su delom u okviru formiranih katastarskih parcela, a delom u okviru ostalog zemljišta u privatnoj ili državnoj svojini. Preko navedenih nekategorisanih puteva i drugih saobraćajnica lokalnog karaktera prostor je povezan s državnim putem IIA reda br. 221 (Knjaževac–Dimitrovgrad). Prilikom definisanja dispozicije solarnih polja planira se maksimalno korišćenje postojeće putne mreže kako bi se u najvećoj mogućoj meri izbegla oštećenja neobrađenih površina, vegetacije uz poljoprivredne površine i ostatke prirodnih ili poluprirodnih staništa. Utvrđeno je da se u obuhvatu Plana ne

5.2.6. Anthropogenic Characteristics of the Area

The largest part of the analyzed area with impact zones is intended for agriculture. It consists of so-called abandoned fields which have not been used for agricultural purposes for years.

A smaller part of the area includes traffic surfaces, namely a municipal road for the settlement of Bačevo and a network of local uncategorized roads, as well as areas of land under forests.

The area covered by the planning documentation and SEA includes the municipal road for the settlement of Bačevo and the network of local uncategorized roads which are partly within formed cadastral parcels and partly within other land in private or state ownership. The area is connected to the state road II A order no. 221 (Knjaževac- Dimitrovgrad) via these uncategorized roads and other local traffic routes. When defining the disposition of the solar fields, it is planned to make maximum use of the existing road network to avoid damage to uncultivated areas, vegetation along agricultural lands, and remnants of natural or semi-natural habitats. It has been determined that there are no state road routes within the scope of the Plan, nalaze trase državnih puteva, shodno Uredbi o kategorizaciji državnih puteva („Službeni glasnik RS", broj 105/13, 119/13 i 93/15) i Referentnom sistemu mreže državnih puteva RS. Planom nisu planirani saobraćajni priključci na državni put, već je planirano da se pristup kompleksu SE ostvari preko opštinskog puta (na k. p. 2736/1 KO Bačevo). Ovaj opštinski put izlazi na trasu državnog puta IIA reda broj 221: Knjaževac – Kalna – Temska – Pirot – Visočka Ržana – Mojinci – Dimitrovgrad.

S obzirom na to da je status zemljišta obuhvaćenog Planom uglavnom poljoprivredno i šumsko zemljište, odnosno opštinski put i nekategorisani putevi u javnoj svojini, katastarske parcele u obuhvatu nisu komunalno opremljene. Na prostoru u obuhvatu Plana nalazi se Magistralni cevovod HDPE DN315 Prtopopinci–Radejna–Dimitrovgrad, koji jednim svojim delom prolazi kroz poljoprivredno i šumsko zemljište u neposrednom okruženju elektrane.

Na prostoru obuhvaćenom Planom postojie sledeći elektroenergetski objekti (EEO): TS10/0,4 kV Lipinci, s nadzemnim 10 kV vodom i raspletom mreže NN, kao i deo NN mreže naselja Bačevo. NN mreža je nadzemna. Nije planirana izgradnja novih EEO. Zadržava se lokacija postojećeg dalekovoda u obuhvatu.

U obuhvatu Plana ili neposrednom okruženju postoji telekomunikaciona mreža.

in accordance with the Regulation on the categorization of state roads ("Official Gazette of RS", numbers 105/13, 119/13, and 93/15) and the Reference System of the State Roads Network of Serbia. The plan does not provide for traffic connections to the state road, but it is planned that access to the SE complex will be achieved via the municipal road (at k.p. 2736/1 KO Bačevo). This municipal road exits onto the route of state road II A order number 221: Knjaževac – Kalna – Temska – Pirot – Visočka Ržana – Mojinci – Dimitrovgrad..

Given that the status of the land covered by the Plan is predominantly agricultural and forested, as well as municipal roads and uncategorized roads in public ownership, the cadastral parcels within the scope are not equipped with utilities. In the area covered by the Plan, the Main Pipeline HDPE DN315 "Prtopopinci – Radejna – Dimitrovgrad" partially passes through "agricultural and forest land in the immediate vicinity of the power plant.

In the area covered by the Plan, there are existing electrical infrastructure components: TS10/0.4kV "Lipinci" with overhead 10 kV lines and a low-voltage network layout, as well as a part of the low-voltage network of the Bačevo settlement. The low-voltage network is overhead. The construction of new electrical infrastructure is not planned. The location of the existing power line within the scope is maintained.

A telecommunications network exists within the scope of the Plan or its immediate surroundings.

5.3. Primena semikvantitativnog metoda višekriterijumske evaluacije

O mogućnosti primene različitih metodoloških pristupa u izradi SPU pisano je u poglavlju 4.2 ove knjige. Ukazano je na preovlađujuću primenu ekspertskih kvalitativnih metoda za evaluaciju planskih rešenja prostornog razvoja koje se primenjuju u SPU, kao i na značaj i mogućnost primene semikvantitativnog metoda višekriterijumske evaluacije koji zagovara autor ove knjige. U tom kontekstu, u nastavku je prezentovan upravo semikvantitativni metod višekriterijumske evaluacije planskih rešenja prostornog razvoja, koji je primenjen u izradi SPU za PDR kompleksa solarne elektrane Brebeks.

Okosnicu primene koncepta semi-kvantitativnog metoda višekriterijumske evaluacije predstavlja nekoliko ključnih metodoloških koraka: definisanje ciljeva SPU i izbor pripadajućih indikatora i evaluacija planskih rešenja. U nastavku su elaborirani navedeni metodološki koraci.

5.3.1. Definisanje ciljeva SPU i izbor indikatora

Prema članu 14. Zakona o strateškoj proceni uticaja na životnu sredinu, opšti i posebni ciljevi SPU definišu se na osnovu zahteva i ciljeva u pogledu zaštite životne sredine u drugim planovima i programima, ciljeva zaštite životne sredine utvrđenih na nivou Republike i međunarodnom nivou, prikupljenih podataka o stanju životne sredine i značajnih pitanja, problema i predloga u pogledu zaštite životne sredine u planu ili programu. Opšti i posebni ciljevi SPU za kompleks solarne elektrane Brebeks sadržani su u strategiji i smernicama Prostornog plana Republike Srbije, Strategije razvoja energetike Republike Srbije i Prostornog plana opštine Dimitrovgrad.

5.3. Application of the Semi-Quantitative Method for Multi-Criteria Evaluation

The possibility of applying various methodological approaches in the development of the SEA is discussed in section 4.2 of this book. It highlights the prevailing use of expert qualitative methods for evaluating spatial development planning solutions applied in the SEA, as well as the significance and possibility of using the semi-quantitative multi-criteria evaluation method advocated by the author of this book. In this context, the semi-quantitative method for multi-criteria evaluation of spatial development planning solutions, which was applied in the creation of the SEA for the solar power plant complex "Brebex", is presented.

The core of the application of the semi-quantitative multi-criteria evaluation method consists of several key methodological steps: defining the objectives of the SEA and choosing corresponding indicators; and evaluating planning solutions. The methodological steps mentioned are elaborated below.

5.3.1. Defining SEA Objectives and Choosing Indicators

According to Article 14 of the Law on Strategic Environmental Assessment, the general and specific objectives of the SEA are defined based on the requirements and objectives regarding environmental protection in other plans and programs, environmental protection goals established at the national and international levels, collected data on the environmental status, and significant issues, problems, and suggestions regarding environmental protection in the plan or program. The general and specific objectives of the SEA for the solar power plant complex "Brebex" are contained in the strategy and guidelines: Spatial Plan of the Republic of Serbia, Energy Development Strategy of the Republic of Serbia, and Spatial Plan of the municipality of Dimitrovgrad.

Opšti ciljevi SPU definisani su na osnovu navedenih planskih dokumenata i na osnovu analize stanja i planiranih aktivnosti na planskom području. Na osnovu opštih ciljeva i na osnovu prostornog obuhvata plana, planiranih sadržaja na području plana, stanja životne sredine na predmetnoj lokaciji i u širem okruženju, definisani su posebni ciljevi SPU, koji su predstavljali osnov za evaluaciju strateških uticaja Plana na životnu sredinu.

Za realizaciju opštih ciljeva utvrđuju se posebni ciljevi SPU u pojedinim oblastima zaštite. Posebni ciljevi SPU predstavljaju konkretan, delom kvantifikovan iskaz opštih ciljeva dat u obliku smernica za promenu i akcija, pomoću kojih će se te promene izvesti. Posebni ciljevi SPU čine metodološko merilo kroz koje se proveravaju efekti Plana na životnu sredinu. Oni treba da obezbede subjektima odlučivanja jasnu sliku o suštinskim uticajima Plana na životnu sredinu. Posebni ciljevi SPU osnov su za evaluaciju strateških teritorijalnih uticaja Plana na životnu sredinu. Oni se definišu na osnovu opštih ciljeva SPU i na osnovu prostornog obuhvata plana, planiranih sadržaja na području Plana i stanja životne sredine na planskom području i u širem okruženju (tabela 12).

Pored ciljeva SPU, od posebnog značaja za procenu uticaja jeste definisanje indikatora (pokazatelja) u odnosu na koje se procenjuju i prate trendovi promena u prostoru i životnoj sredini. Za svaki poseban cilj SPU određuje se jedan ili više pripadajućih indikatora. U slučaju SPU za Plan kompleksa solarne elektrane Brebeks, izbor indikatora je izvršen iz Osnovnog seta UN indikatora održivog razvoja, u skladu

The general objectives of the SEA are defined based on the aforementioned planning documents and based on an analysis of the state and planned activities in the planning area. Based on the general objectives and based on: the spatial scope of the plan, planned contents in the plan area, the state of the environment at the specific location and its wider surroundings, specific objectives of the SEA are defined which formed the basis for evaluating the strategic impacts of the plan on the environment.

To achieve the general objectives, specific SEA objectives are established in various areas of protection. These specific SEA objectives represent a concrete, partly quantified expression of the general objectives, formulated as guidelines for change and actions that will facilitate these changes. The specific SEA objectives provide a methodological standard through which the effects of the Plan on the environment are assessed. They aim to give decision-makers a clear picture of the essential impacts of the Plan on the environment. These specific objectives form the basis for evaluating the strategic territorial impacts of the Plan on the environment. They are defined based on the general SEA objectives and considering the spatial scope of the Plan, the planned contents in the area of the Plan, the state of the environment in the planning area, and its wider surroundings (Table 12).

In addition to the SEA objectives, defining indicators (measures) is especially significant for assessing impacts, against which trends in changes in space and the environment are evaluated and monitored. For each specific SEA objective, one or more corresponding indicators are determined. In the case of the SEA for the “Brebex” solar power plant complex Plan, the choice of indicators was made sa Uputstvom koje je izdalo Ministarstvo nauke i zaštite životne sredine u februaru 2007. god. i Pravilnikom o nacionalnoj listi indikatora zaštite životne sredine („Službeni glasnik RS”, broj 37/2011). Ovaj set indikatora zasnovan je na konceptu „uzrok–posledica–odgovor”. Indikatori uzroka označavaju ljudske aktivnosti, procese i odnose koji utiču na životnu sredinu, indikatori posledica označavaju stanje životne sredine, dok indikatori odgovora definišu političke opcije i ostale reakcije u cilju promena posledica po životnu sredinu. Set indikatora u potpunosti odražava principe i ciljeve održivog razvoja. Izbor indikatora navedenih u tabeli 12 u skladu je s planiranim aktivnostima na području Plana i njihovim mogućim uticajima na kvalitet životne sredine i poslužio je za evaluaciju planskih rešenja.

from the “UN Basic Set of Indicators of Sustainable Development,” in accordance with the guidelines issued by the Ministry of Science and Environmental Protection in February 2007 and the Regulation on the national list of environmental protection indicators (“Official Gazette of RS”, number 37/2011). This set of indicators is based on the “cause-effect-response” concept. “Cause” indicators signify human activities, processes, and relationships that impact the environment, “effect” indicators denote the state of the environment, while “response” indicators define policy options and other reactions aimed at changing the environmental “effects”. The set of indicators fully reflects the principles and objectives of sustainable development. The choice of indicators listed in Table 12 is in line with the planned activities in the area of the Plan and their potential impacts on environmental quality and has been used to evaluate planning solutions.

Tabela 12. Ciljevi SPU i pripadajući indikatori po receptorima životne sredine

Receptori životne sredine	Posebni cilj strateške procene	Indikatori
Zaštita biodiverziteta	1. Smanjiti štetan uticaj na faunu	- Broj i status potencijalno ugroženih vrsta
	2. Smanjiti štetan uticaj na floru	- Broj i status potencijalno ugroženih vrsta
	3. Očuvati biodiverzitet i staništa	- Diverzitet vrsta*
Zaštita osnovnih činilaca životne sredine	4. Očuvati kvalitet vazduha	- Broj dana kad je prekoračena granična vrednost emisije za PM čestice, CO, SO_2 i NO_2 kao posledica izgradnje solarne elektrane*
	5. Smanjiti uticaj na klimatske promene	- Doprinos promeni emisije GHG (CO_2, N_2O, CH_4, SF_6, HFC, PFC (%)*, kao rezultat izgradnje solarne elektrane
	6. Očuvati kvalitet voda	- *Serbian Water Quality Index* (SWQI)* - Emisije zagađujućih materija u vodna tela* - Kvalitet vode za piće*
	7. Očuvati kvalitet zemljišta	- Procenat kontaminiranih površina - Promena načina korišćenja zemljišta*
Zaštita predela	8. Zaštita predela	- Broj i prostorna dispozicija planiranih solarnih panela - Izloženost/vidljivost lokacije
Zaštita kulturnog nasleđa	9. Očuvati kulturno nasleđe	- Broj potencijalno ugoženih lokaliteta na kojima postoje objekti kulturne baštine / arheološki ostaci
Zaštita od nejonizujućeg zračenja	10. Smanjiti nejonizujuće zračenje	- Izvori nejonizujućeg zračenja od posebnog interesa* - Broj objekata koji mogu biti pod uticajem nejonizujućeg zračenja kao posledica realizacije projekta solarne elektrane
Stanovništvo i socio-ekonomski razvoj	11. Smanjiti izloženost stanovništva uticajima projekta	- Broj objekata u zoni s povećanim nivoom buke i rizikom od udesa - Ukupni indikator buke*
	12. Podsticati ekonomski rast i korišćenje OIE	- Broj zaposlenih na izgradnji i u eksploataciji solarne elektrane - Prihod lokalne zajednice, firmi i pojedinaca od realizacije projekta - Potrošnja primarne energije iz obnovljivih izvora*

Table 12. SEA objectives and corresponding environmental receptors

Environmental Receptors	Special goal of the strategic assessment	Indicators
Protection of biovivesity	**1. Reduce harmful impact on fauna**	- Number and status of potentially endangered species
	2. Reduce harmful impact on flora	- Number and status of potentially endangered species
	3. Preserve biodiversity and habitats	- Species diversity *
Protection of basic elements of the environment	**4. Preserve air quality**	- Number of days when the emission limit value for PM particles, CO, SO2, and NO2 was exceeded as a result of the construction of the solar power plant*
	5. Reduce impact on climate change	- Contribution to the change in GHG emissions (CO2, N2O, CH4, SF6, HFC, PFC (%)) *, as a result of the construction of the solar power plant
	6. Preserve water quality	- Serbian Water Quality Index (SWQI)* - Emissions of pollutants into water bodies* - Drinking water quality*
	7. Preserve soil quality	- Percentage of contaminated surfaces - Change in land use *
Protection of the landscape	**8. Protect landscapes**	- Number and spatial arrangement of planned solar panels - Exposure/visibility of the location
Protection of cultural heritage	**9. Preserve cultural heritage**	- Number of potentially endangered sites with cultural heritage/archaeological remains
Protection from non-ionising rediation	**10. Reduce non-ionising radiation**	- Sources of non-ionizing radiation of special interest * - Number of buildings that may be affected by non-ionizing radiation as a result of the solar power plant project
Population and socio-economic development	**11. Reduce population exposure to project impacts**	- Number of buildings in a zone with increased noise levels and accident risk - Total noise indicator *
	12. Promote economic growth and the use of renewable energy sources	- Number of employees involved in the construction and operation of the solar power plant - Revenue of the local community, companies, and individuals from the project implementation - Consumption of primary energy from renewable sources *

Značaj ciljeva i indikatora SPU (tabela 12) u semikvantitativnom metodu višekriterijumske evaluacije izuzetno je veliki. Naime, upravo se u odnosu na ciljeve SPU i pripadajuće indikatore sprovodi postupak evaluacije planskih rešenja. To se ostvaruje formiranjem matrica u kojima se planska rešenja ukrštaju s ciljevima SPU i pripadajućim indikatorima, a zatim ocenjuju u odnosu na definisane kriterijume (tabele 14–17).

The significance of SEA (Strategic Environmental Assessment) objectives and indicators (Table 12) in the semi-quantitative method of multi-criteria evaluation is extremely high. In fact, the evaluation process of planning solutions is conducted with respect to SEA objectives and corresponding indicators. This is achieved by forming matrices in which planning solutions intersect with SEA objectives and corresponding indicators, and are then evaluated against defined criteria (Tables 14-17).

5.3.2. Procena uticaja na životnu sredinu

5.3.2. Environmental Impact Assessment

Osnovni cilj izrade SPU jeste sagledavanje svih aspekata mogućih uticaja (pozitivnih i negativnih) koji mogu nastati u životnoj sredini kao rezultat ili posledica sprovođenja određene politike prostornog razvoja. U SPU se procenjuju budući trendovi u životnoj sredini, predviđaju smernice za implementaciju planske koncepcije prostornog razvoja kojima se sprečavaju konflikti u prostoru i iznose zaključci na osnovu kojih se donose odluke o budućem prostornom razvoju na određenom prostoru.

Plan kompleksa solarne elektrane Brebekspredstavljaće planski osnov za izgradnju solarne elektrane, koja prema karakteristikama funkcionisanja može ostvariti određene pozitivne efekte u životnoj sredini, ali i implicirati određene negativne efekte na kvalitet životne sredine ili pojedine njene elemente. U tom kontekstu je kroz postupak SPU bilo potrebno sagledati sve moguće promene u životnoj sredini koje se odnose na prostorne a ne na tehničke apsekte izgradnje i funkcionisanja solarne elektrane.

Inicijalno sagledavanje prostornog aspekta u okviru SPU sprovodi se poređenjem

The primary objective of conducting a Strategic Environmental Assessment (SEA) is to consider all aspects of potential impacts (both positive and negative) that may arise in the environment as a result of or consequent to the implementation of certain spatial development policies. The SEA evaluates future environmental trends, predicts guidelines for the implementation of spatial development planning concepts to prevent conflicts in space, and presents conclusions on which decisions about future spatial development in a particular area are made.

The "Brebex" solar power plant complex plan will serve as a planning basis for the construction of a solar power plant that, according to operational characteristics, can achieve certain positive effects on the environment but may also imply certain negative effects on environmental quality or its individual elements. In this context, the SEA process needed to consider all possible changes in the environment related to spatial, not technical aspects of the construction and operation of the solar power plant.

The initial consideration of the spatial aspect within the SEA is carried out by varijantnih rešenja prostornog razvoja, a zatim se odabrana varijanta procenjuje u odnosu na pojedinačna planska rešenja. Ovo je pod uslovom da varijantna rešenja nisu prethodno razmatrana u okviru Prethodne studije opravdanosti, što nije redak slučaj.

comparing alternative spatial development solutions, and then the selected option is assessed in relation to individual planning solutions. This is under the condition that alternative solutions have not been previously considered within a Preliminary Feasibility Study, which is not uncommon.

5.3.2.1. Procena varijantnih rešenja

5.3.2.1. Assessment of alternative solutions

Varijantna rešenja Plana predstavljaju različite racionalne načine, sredstva i mere realizacije ciljeva Plana u pojedinim sektorima razvoja,kroz razmatranje mogućnosti korišćenja određenog prostora za specifične namene i aktivnosti. Ukupni efekti plana, pa i uticaji na životnu sredinu, mogu se efikasno utvrditi poređenjem s postojećim stanjem, s ciljevima i rešenjima plana.

Zakon o strateškoj proceni uticaja na životnu sredinu ne propisuje šta su to varijantna rešenja Plana koja podležu strateškoj proceni uticaja, ali u praksi se moraju razmatrati najmanje dve varijante: varijanta primene Plana i varijanta da se Plan ne implementira. S obzirom na to da je Plan detaljne regulacije najniži hijerahijski stepen u hijerarhiji planskih dokumenata, i s obzirom na postojeću i planiranu namenu u njegovom obuhvatu, razmatranje navedenih varijanti bilo je usmereno na prostornu organizaciju zona u okviru Plana i njihovo usaglašavanje s rezultatima izvršenih prostornih analiza i opservacijama biodiverziteta na lokaciji.

Za procenu uticaja varijantnih rešenja formiraju se matrice gde se procenjuje uticaj varijantnih rešenja Plana po oblastima SPU. Ilustrativni prikaz matrica za vrednovanje varijantnih rešenja za Plan kompleksa solarne elektrane Brebeks prikazan je u tabeli 13.

Alternative plan solutions represent different rational ways, means, and measures of achieving the plan's goals in specific development sectors, through considering the use of certain spaces for specific purposes and activities. The overall effects of the plan, including impacts on the environment, can be effectively determined by comparison with the current state, with the objectives and solutions of the plan.

The Law on Strategic Environmental Assessment does not prescribe what the alternative plan solutions that are subject to strategic environmental impact assessment are, but in practice, at least two alternatives must be considered: the variant where the plan is implemented; and the variant where the plan is not implemented. Given that the Detailed Regulation Plan is the lowest hierarchical level in the hierarchy of planning documents, and considering the existing and planned use within its scope, the consideration of these variants was focused on the spatial organization of zones within the Plan and their alignment with the results of spatial analyses and biodiversity observations at the location.

To assess the impact of alternative solutions, matrices are formed where the impact of the Plan's alternative solutions is assessed across SEA areas. An illustrative display of the matrices for evaluating alternative solutions for the "Brebex" solar power plant complex is shown in Table 13.

Tabela 13. Ilustrativni prikaz vrednovanja varijantnih rešenja u formi matrica

Table 13. Illustrative display of evaluating alternative solutions in matrix form

Oblast SPU / SEA area	Varijantna rešenja / Alternative solutions	Ciljevi SPU / SEA goals											
		1	2	3	4	5	6	7	8	9	10	11	12
Areas for electricity production in the solar power plant – SE zone	A	–	–	+	0	–	0	–	0	+	0	0	+
Areas for agricultural activity – P and PZ zones	B	0	0	0	0	0	0	–	0	–	0	0	–
Areas for forest land – Š zone	A	–	–	+	0	–	0	–	0	+	0	0	+
	B	0	0	0	0	0	0	–	0	–	0	0	–
Areas for electricity production in the solar power plant – SE zone	A	–	–	+	0	–	0	–	0	+	0	0	+
Areas for agricultural activity – P and PZ zones	B	0	0	0	0	0	0	–	0	–	0	0	–
⋮	A	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	B	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
N	A	...	...	...	...	...	...	...	...	...	...	...	...
	B	...	...	...	...	...	...	...	...	...	...	...	...

Značenje simbola:

+ – ukupno pozitivan uticaj

– – ukupno negativan uticaj

0 – nema direktnog uticaja ili nejasan uticaj

A – varijanta s primenom Plana

B – varijanta da se Plan ne implementira

Meaning of symbols:

+ overall positive impact;

- overall negative impact;

0 – no direct impact or unclear impact;

A – alternative with plan implementation;

B – alternative where the plan is not implemented.

Procena uticaja varijantnih rešenja odvijala se obično kroz nekoliko faza, što je delimično bio slučaj i u SPU za kompleks solarne elektrane Brebeks:

- Faza I – Inicijalno pozicioniranje solarnih panela i funkcionalnih zona u okviru Plana, zasnovano na prvobitnoj želji investitora, bez prostornih analiza i sagledavanja mogućih uticaja na životnu sredinu. Ova faza poslužila je kao osnov za izradu prostornih analiza i ishodovanje uslova relevantnih institucija – imalaca javnih ovlašćenja;
- Faza II – Pozicioniranje solarnih panela i funkcionalnih zona u okviru Plana, zasnovano na uslovima i smernicama relevantnih institucija – imalaca javnih ovlašćenja;
- Faza III – Pozicioniranje solarnih panela i funkcionalnih zona u okviru plana, zasnovano na izvršenim detaljnim prostornim analizama i opservacijama biodiverziteta;
- Faza IV – Konačna varijanta pozicioniranja solarnih panela i funkcionalnih zona u okviru Plana u odnosu na rezultate prethodnih faza i uz saglasnost relevantnih institucija – imalaca javnih ovlašćenja.

Nakon izbora najpovoljnijeg varijantnog rešenja, koje se baziralo na proceni trendova u životnoj sredini koji mogu nastati kao rezultat ili posledica realizacije varijantih rešenja, pristupilo se evaluacije planskih rešenja primenom semikvantitativnog metoda.

The assessment of the impact of alternative solutions typically took place over several phases, which was partially the case in the SEA for the “Brebex” solar power plant complex:

- Phase I – Initial positioning of solar panels and functional zones within the Plan based on the original desire of the investor, without spatial analyses and consideration of potential environmental impacts. This phase served as a basis for conducting spatial analyses and obtaining conditions from relevant institutions with public authority;
- Phase II – Positioning of solar panels and functional zones within the Plan based on the conditions and guidelines of relevant institutions with public authority;
- Phase III – Positioning of solar panels and functional zones within the Plan based on detailed spatial analyses and biodiversity observations;
- Phase IV – Final variant of positioning solar panels and functional zones within the Plan in relation to the results of previous phases and with the consent of relevant institutions with public authority.

After selecting the most favourable alternative solution, which was based on the assessment of environmental trends that could arise as a result or consequence of the implementation of alternative solutions, the evaluation of planning solutions proceeded using a semi-quantitative method.

5.3.2.2. Evaluacija karakteristika i značaja uticaja planskih rešenja s definisanjem kriterijuma za evaluaciju

5.3.2.2. Evaluation of the characteristics and significance of the impacts of planning solutions with the definition of evaluation criteria

Evaluacija karakteristika i značaja uticaja planskih rešenja u SPU izvršena je primenom semikvantitativnog metoda u odnosu na grupe kriterijuma kojima se utvrđuju značaj, prostorne razmere, verovatnoća i trajanje uticaja planskih rešenja, kao i u odnosu na ciljeve i indikatore SPU, kako bi se identifikovali mogući (strateški) uticaji planskih rešenja formulisanih u planu. Višekriterijumska evaluacije izvršena je u odnosu na kriterijume[3] u narednim tabelama. U tabeli 14 prikazani su kriterijumi za vrednovanje planskih rešenja.

The evaluation of the characteristics and significance of the impacts of planning solutions in the SEA was performed using a semi-quantitative method in relation to groups of criteria that determine: significance; spatial extent; probability; and duration of impacts of planning solutions; as well as in relation to the objectives and indicators of the SEA, in order to identify possible (strategic) impacts of planning solutions formulated in the Plan. Multi-criteria evaluation was carried out in relation to criteria[3] in the following Tables. Table 14 shows the criteria for evaluating planning solutions.

Tabela 14. Kriterijumi za ocenjivanje veličine uticaja

Table 14. Criteria for assessing the magnitude of impact

Veličina uticaja / Magnitude of impact	Oznaka / Label	Opis / Description
Kritičan / Critical	- 3	Preopterećuje kapacitet prostora / Overloads the capacity of the space
Veći / Higher	- 2	U većoj meri narušava životnu sredinu / Significantly damages the environment
Manji / Smaller	- 1	U manjoj meri narušava životnu sredinu / Minimally damages the environment
Nema uticaja / No impact	0	Nema uticaja na životnu sredinu / No impact on the environment
Pozitivan / Positive	+ 1	Manje pozitivne promene u životnoj sredini / Minor positive changes in the environment
Povoljan / Favourable	+ 2	Povoljne promene kvaliteta životne sredine / Favorable changes to environmental quality

3 Prikazane su samo osnovne grupe kriterijuma na osnovu kojih se procenjuje strateški značaj prostornih uticaja planskih rešenja, bez prikaza specifičnih kriterijuma. Za svaki kriterijum u osnovnim grupama kriterijuma u okviru SPU za Plan kompleksa solarne elektrane Brebeks, određeni su specifični kriterijumi za svako pojedinačno plansko rešenje. Određivanje specifičnih kriterijuma, s jedna strane, uslovljeno je profesionalnom diskrecijom na koju se odlučio autor ove knjige, a s druge strane iziskivalo bi znatno detaljniji i obimniji nivo obrade od onog koji je konceptualno osmišljen za ovu knjigu.

3 Only the basic groups of criteria for assessing the strategic significance of spatial impacts of planning solutions are shown, without displaying specific criteria. For each criterion in the basic groups, specific criteria for each individual planning solution were determined within the SEA for the "Brebex" solar power plant complex plan. The determination of specific criteria, on one hand, is conditioned by the professional discretion chosen by the author of this book, and on the other hand, would require a much more detailed and extensive level of processing than what was conceptually designed for this book.

U tabeli 15 prikazani su kriterijumi za vrednovanje prostornih razmera mogućih uticaja.

In Table 15, the criteria for evaluating the spatial dimensions of potential impacts are shown.

Tabela 15. Kriterijumi za vrednovanje prostornih razmera mogućih uticaja
Table 15. Criteria for evaluating the spatial dimensions of potential impacts

Značaj uticaja / Impact significance	Oznaka / Label	Opis / Decription
Nacionalni / National	N	Moguć uticaj na nacionalnom nivou / Possible national impact
Gradski / Municipal	O	Moguć uticaj na području opštine / Possible municipal impact
Lokalni / Local	L	Moguć uticaj lokalnog karaktera / Possible local impact

Verovatnoća da će se neki procenjeni uticaj dogoditi u stvarnosti takođe predstavlja važan kriterijum za donošenje odluka u toku izrade plana. Verovatnoća uticaja određuje se prema skali prikazanoj u tabeli 16.

The likelihood that a projected impact will occur in reality also represents an important criterion for decision-making during the planning process. The probability of the impact is determined according to the scale shown in Table 16.

Tabela 16. Skala za procenu verovatnoće uticaja
Table 16. Impact probability assessment scale

Verovatnoća / Probability	Oznaka / Label	Opis / Decription
100%	**S**	uticaj izvestan / impact certain
Više od / over 50%	**V**	uticaj verovatan / impact probable
Manje od / Less than 50%	**M**	uticaj moguć / impact possible

Pored toga, dodatni kriterijumi mogu se izvesti prema vremenu trajanja uticaja, odnosno posledica. U tom smislu mogu se definisati privremeno-povremeni (P) i dugotrajni (D) efekti.

Additionally, further criteria can be derived based on the duration of the impact or its consequences. In this sense, temporary-intermittent (T) and long-lasting (L) effects can be defined.

Usvaja se: Uticaji od strateškog značaja za Plan za kompleks solarne elektrane Brebeks jesu oni koji imaju jak ili veći (pozitivan ili negativan) efekat na celom području Plana ili na prostoru koji je veći od prostora u granicama Plana (opštinski, odnosno nacionalni nivo) prema kriterijumima u tabeli 17.

It is adopted that: Impacts of strategic importance for the Plan for the "Brebex" solar power complex are those that have a strong or greater (positive or negative) effect across the entire planning area or on a space larger than the area within the Plan's boundaries (municipal and/or national level) according to the criteria in Table 17.

Tabela 17. Kriterijumi za evaluaciju značaja uticaja
Table 17. Criteria for evaluating impact significance

Razmere / Scale	Veličina / Magnitude		Oznaka značajnih uticaja / Significant impact label
Nacionalni nivo / National Level: N	Jak pozitivan uticaj / Strong positive impact	+3	N +3
	Veći pozitivan uticaj / Stronger positive impact	+2	N +2
	Jak negativan uticaj / Strong negative impact	-3	N -3
	Veći negativan uticaj / More severe negative impact	-2	N -2
Opštinski nivo / Municipal level: G	Jak pozitivan uticaj / Strong positive impact	+3	G +3
	Veći pozitivan uticaj / Stronger positive impact	+2	G +2
	Jak negativan uticaj / Strong negative impact	-3	G -3
	Veći negativan uticaj / More severe negative impact	-2	G -2
Lokalni nivo / Local level: L	Jak pozitivan uticaj / Strong positive impact	+3	L +3
	Veći pozitivan uticaj / Stronger positive impact	+2	L +2
	Jak negativan uticaj / Strong negative impact	-3	L -3
	Veći negativan uticaj / More severe negative impact	-2	L -2

Na osnovu kriterijuma procene veličine, prostornih razmera, procene verovatnoće i trajanja uticaja konkretnih planskih rešenja iz Plana (tabela 18) na ciljeve SPU i pripadajuće indikatore, sprovodi se postupak višekriterijumske evaluacije i određivanje značaja identifikovanih uticaja PDR-a.

Based on the criteria for assessing the size, spatial dimensions, probability, and duration of impacts from specific planning solutions in the Plan (Table 18) on the objectives of the Strategic Environmental Assessment (SEA) and associated indicators, a multi-criteria evaluation process is conducted to determine the significance of the identified impacts of the Spatial Development Regulation (SDR).

Tabela 18. Ilustrativni prikaz dela planskih rešenja obuhvaćenih procenom uticaja

Table 18. Illustrative depiction of parts of the planning solutions covered by the impact assessment

Red. Br. No.	Plansko rešenje / Planning solution
1	Površine za proizvodnju električne energije u solarnoj elektrani – zona SE / Areas for electricity production in the solar power plant – SE zone
2	Površine za poljoprivrednu delatnost – zone P i PZ / Areas for agricultural activity – P and PZ zones
3	Površine za šumsko zemljište – zona Š / Areas for forest land – Š zone
4	Površina za izgradnju elektroenergetskog kompleksa u funkciji solarne elektrane (TS, PRP,-SkE) – zona EE / Area for the construction of the power complex serving the solar power plant (TS, PRP, -SkE) – EE zone
⋮	⋮
n	...

Procena uticaja na životnu sredinu i elemente održivog razvoja izvršena je u matricama, odnosno u tabelama 19, 20 i 21.

S obzirom na to da je način elaboriranja (prikaza) rezultata dobijenih primenom semikvantitativnog metoda višekriterijumske evaluacije planskih rešenja ključan za donošenje optimalnih odluka o implementaciji Plana od strane donosioca odluka, koji često nemaju adekvatna profesionalna znanja u oblasti zaštite životne sredine, izuzetno je važno da prikaz dobijenih rezultata bude jasno, nedvosmisleno i razumljivo prikazan u SPU.

The environmental impact assessment and the assessment of elements of sustainable development were performed using matrices, specifically in Tables 19, 20, and 21.

Given that the method of elaborating (presenting) the results obtained by using the semi-quantitative method of multi-criteria evaluation of planning solutions is crucial for making optimal decisions on the implementation of the Plan by decision-makers who often lack adequate professional knowledge in environmental protection, it is extremely important that the presentation of the results be clear, unambiguous, and understandable in the Strategic Environmental Assessment (SEA).

U skladu sa ovom konstatacijom, za prikaz rezultata procene uticaja svakog pojedinačnog planskog rešenja na ciljeve SPU korišćeni su grafikoni (slika 41) koji u potpunosti reprezentuju rezultate dobijene u matricama za višekriterijumsku evaluaciju planskih rešenja. Levo od Y ose u grafikonima se prikazuju negativni uticaji planskog rešenja i njegov značaj, dok su desno od Y ose prikazani pozitivni uticaji planskog rešenja i njegov značaj. Tako se jednostavnim pogledom na grafikon mogu sagledati svi uticaji svakog pojedinačnog planskog rešenja i njegov značaj u odnosu na ciljeve SPU. U matricama (tabele 19 i 20) ukrštaju se planska rešenja s ciljevima SPU i ocenjuju prema osnovnim grupama kriterijuma: za ocenu veličine uticaja (tabela 14) i za prostornu razmeru uticaja (tabela 15). U odnosu na navedene dve osnovne grupe kriterijuma identifikuju se strateški značajni uticaji (tabela 17), kojima se dodatno određuju vrednosti prema preostale dve osnovne grupe kriterijuma: verovatnoći uticaja (tabela 16) i vremenu trajanja/učestanosti uticaja. Ilustrativni matrični prikaz višekriterijumske evaluacije planskih rešenja dat je u tabelama 19 i 20.

In line with this statement, graphs (Figure 41) were used to display the results of the impact assessment of each individual planning solution on the objectives of the SEA. These graphs fully represent the results obtained in the matrices for the multi-criteria evaluation of planning solutions. On the left side of the Y-axis in the graphs, the negative impacts of the planning solution and its significance are shown, while on the right side of the Y-axis, the positive impacts and their significance are displayed. This allows for a simple visual overview of all the impacts of each individual planning solution and its significance in relation to the objectives of the SEA. In the matrices (Tables 19 and 20), planning solutions are cross-referenced with the objectives of the SEA and assessed according to the basic groups of criteria: for the assessment of the size of the impact (Table 14) and for the spatial scale of the impact (Table 15). Based on these two basic groups of criteria, strategically significant impacts (Table 17) are identified, to which values are further assigned according to the remaining two basic groups of criteria: the probability of impact (Table 16) and the duration/frequency of the impact. An illustrative matrix display of the multi-criteria evaluation of planning solutions is provided in Tables 19 and 20.

Tabela 19. Ilustrativni prikaz procene veličine uticaja planskih rešenja na životnu sredinu

Planska rešenja	Ciljevi SPU											
	Smanjiti štetan uticaj na faunu	Smanjiti štetan uticaj na floru	Očuvati biodiverzitet i staništa	Očuvati kvalitet vazduha	Smanjiti uticaj na klimatske promene	Očuvati kvalitet voda	Očuvati kvalitet zemljišta	Zaštititi predeo	Očuvati kulturno nasleđe	Smanjiti nejonizujuće zračenje	Smanjiti izloženost stanovništva uticajima projekta	Podsticati ekonomski rast i korišćenje OIE
Površine za proizvodnju električne energije u solarnoj elektrani – zona SE	-1	-1	-1	+1	+2	-1	-1	-1	-2	0	0	+3
Površine za poljoprivrednu delatnost – zone P i PZ	0	0	0	0	0	0	-1	0	0	0	0	0
Površine za šumsko zemljište – zona Š	+1	+1	+1	0	0	0	+1	+2	0	0	0	0
Površina za izgradnju elektroenergetskog kompleksa u funkciji solarne elektrane (TS, PRP,-SkE) – zona EE	0	0	0	0	0	-1	-1	-1	-1	-1	0	+3
⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝	⁝
n	...	...	...	...	...	...	...	...	...	...	...	...

* kriterijumi prema tabeli 14

Table 19. Illustrative display of the assessment of the impact size of planning solutions on the environment

Planning solutions	Ciljevi SEA / SEA objectives											
	Reduce harmful impact on fauna	Reduce harmful impact on flora	Preserve biodiversity and habitats	Preserve air quality	Reduce impact on climate change	Preserve water quality	Preserve soil quality	Protect landscapes	Preserve cultural heritage	Reduce non-ionizing radiation	Reduce population exposure to project impacts	Encourage economic growth and use of RES
Areas for electricity production in the solar power plant – SE zone	-1	-1	-1	+1	+2	-1	-1	-1	-2	0	0	+3
Areas for agricultural activity – P and PZ zones	0	0	0	0	0	0	-1	0	0	0	0	0
Areas for forest land – Š zone	+1	+1	+1	0	0	0	+1	+2	0	0	0	0
Area for the construction of the power complex serving the solar power plant (TS, PRP, -SkE) – EE zone	0	0	0	0	0	-1	-1	-1	-1	-1	0	+3
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
N	...	...	...	...	...	...	...	...	...	...	...	...

*Criteria according to Table 14.

Tabela 20. Ilustrativni prikaz procena prostornih razmera uticaja planskih rešenja na životnu sredinu

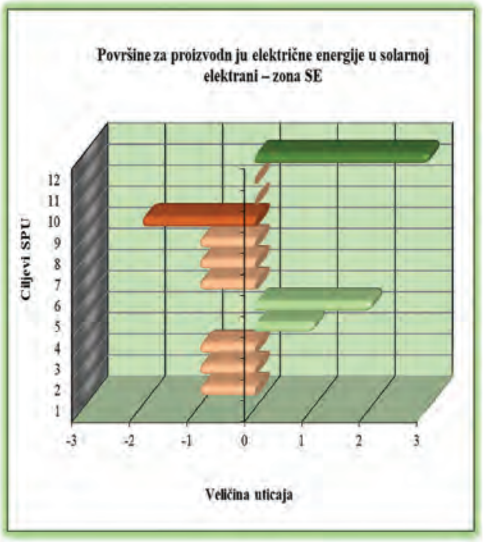
Planska rešenja	Ciljevi SPU											
	Smanjiti štetan uticaj na faunu	Smanjiti štetan uticaj na floru	Očuvati biodiverzitet i staništa	Očuvati kvalitet vazduha	Smanjiti uticaj na klimatske promene	Očuvati kvalitet voda	Očuvati kvalitet zemljišta	Zaštititi predelo	Očuvati kulturno nasleđe	Smanjiti nejonizujuće zračenje	Smanjiti izloženost stanovništva uticajima projekta	Podsticati ekonomski rast i korišćenje OIE
Površine za proizvodnju električne energije u solarnoj elektrani – zona SE	L	L	L	L	L	L	L	L	N			N
Površine za poljoprivrednu delatnost – zone P i PZ							L					
Površine za šumsko zemljište – zona Š	L	L	L				L	L				
Površina za izgradnju elektroenergetskog kompleksa u funkciji solarne elektrane (TS, PRP,-SkE) – zona EE						L	L	L	N	L		N
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
n	...	...	...	...	...	...	...	...	...	...	...	...

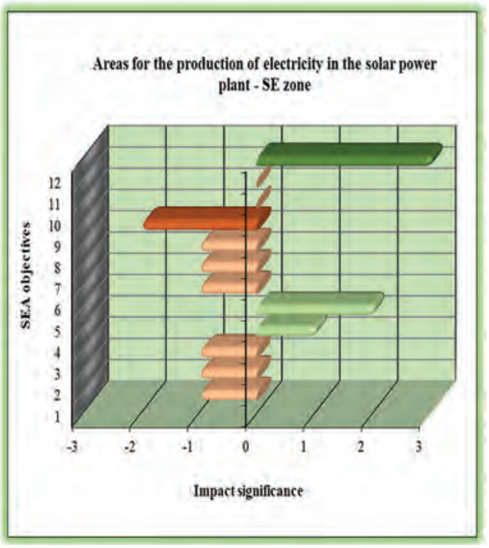
* kriterijumi prema tabeli 15

Table 20. Illustrative display of the assessments of the spatial dimensions of the impacts of planning solutions on the environment

Planning Solutions	SEA objectives											
	Reduce harmful impact on fauna	Reduce harmful impact on flora	Preserve biodiversity and habitats	Preserve air quality	Reduce impact on climate change	Preserve water quality	Protect landscapes	Zaštititi predelo	Preserve cultural heritage	educe non-ionizing radiation	Reduce population exposure to project impacts	Reduce population exposure to project impacts
Areas for electricity production in the solar power plant – SE zone	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**N**			**N**
Areas for agricultural activity – P and PZ zones							**L**					
Areas for forest land – Š zone	**L**	**L**	**L**				**L**	**L**				
Area for the construction of the power complex serving the solar power plant (TS, PRP, -SkE) – EE zone						**L**	**L**	**L**	**N**	**L**		**N**
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
n	...	...	...	...	...	...	...	...	...	...	...	...

***Criteria according to Table 15**.





Oznaka (negativni) / Label (negative)	Značaj uticaja / Impact significance	Oznaka (pozitivni) / Label (positive)
N	Nacionalni / National	N
O	Municipal / Opštinski	O
L	Local / Lokalni	L

Slika 41. Grafikoni za prikaz rezultata procene uticaja

Figure 41. Graphs for displaying the results of an impact assessment

Identifikaciji strateški značajnih uticaja i drugih (manjih) mogućih uticaja pojedinačnih planskih rešenja na životnu sredinu (tabela 21) pristupa se nakon sprovedenog postupka višekriterijumske evaluacije planskih rešenja i prikaza rezultata evaluacije u formi grafikona (slika 49).

Utvrđenim strateški značajnim uticajima određuje se rang uticaja prema svim osnovnim grupama kriterijuma (tabele 14, 15 i 16) i kriterijumima za procenu vremena trajanja uticaja. Rang uticaja određuje se za svako pojedinačno plansko rešenje prema kome se ostvaruje strateški značajan uticaj (pozitivan i negativan).

Identification of strategically significant impacts and other (smaller) potential impacts of individual planning solutions on the environment (Table 21) is approached after a multi-criteria evaluation of planning solutions has been conducted and the results of the evaluation are presented in the form of graphs (Figure 49).

The established strategically significant impacts are ranked according to all basic groups of criteria (Tables 14, 15, and 16) and criteria for assessing the duration of impacts. The impact rank is determined for each individual planning solution through which a strategically significant impact (both positive and negative) is realized.

Identifikovanje manjih mogućih uticaja, koji nemaju strateški karakter, takođe je važno zbog sagledavanja celovite slike o svim implikacijama koje mogu nastati u prostoru kao posledica implementacije planskih propozicija. Samo celovitim sagledavanjem potencijalnih problema moguće je definisati odgovarajuće smernice za minimiziranje ili potpuno eliminisanje potencijalnih konflikata u prostoru.

Identifying smaller possible impacts, which do not have a strategic character, is also important for understanding the complete picture of all implications that may arise in the space as a result of the implementation of planning propositions. Only by comprehensively viewing potential problems is it possible to define appropriate guidelines for minimizing or completely eliminating potential conflicts in the space.

Tabela 21. Ilustrativni prikaz identifikacije strateški značajnih i drugih uticaja planskih rešenja na životnu sredinu

Planska rešenja	Identifikacija strateških uticaja		Obrazloženje	Manji uticaji na ciljeve SPU	Obrazloženje
	Cilj SPU	Rang			
Površine za proizvodnju električne energije u solarnoj elektrani – zona SE	9	**N-2 / M / D**	Izgradnja solarne elektrane ostvariće jak pozitivan uticaj na povećanje korišćenja OIE i poboljšanje portfolija RS u ovoj oblasti. Ovaj strateški značajni uticaj prevazilazi okvire planskog dokumenta i ima nacionalni značaj. S obzirom na neistraženost planskog područja u kontekstu nepokretnih kulturnih dobara, teorijski je moguće da se tokom radova naiđe i dođe do oštećenja ovakvih nalaza. Ovaj uticaj je, međutim, uslovan jer su Planom predviđene mere preventivne zaštite, kao i vršenje prethodnih preventivnih arheoloških istraživanja na lokaciji.	**1, 2, 3, 6, 4, 5**	Imajući u vidu rezultate opservacija biodiverziteta i primenu principa preventivne zaštite u planiranju, samo su teorijski mogući manji negativni uticaji na biodiverzitet i činioce životne sredine i uglavnom se mogu desiti u toku izgradnje, pa je njihov karakter privremen, dok se pozitivni uticaji odnose na klimatske promene i kvalitet vazduha.
	12	**N+3 / S / D**			

Planska rešenja	Identifikacija strateških uticaja		Obrazloženje	Manji uticaji na ciljeve SPU	Obrazloženje
	Cilj SPU	Rang			
Površine za poljoprivrednu delatnost – zone P i PZ	/	/	/	7	Mogućnost korišćenja hemizacije u poljoprivredi može imati negativan uticaj na kvalitet zemljišta na lokaciji.
Površine za šumsko zemljište – zona Š	/	/	/	1, 2, 3, 7, 8	Realizacijom ovog planskog rešenja ostvariće se pozitivni uticaji na biodiverzitet i predeo.
Površina za izgradnju elektroenergetskog kompleksa u funkciji solarne elektrane (TS, PRP,-SkE) – zona EE	12	N+3 / S / D	Strateški začajan pozitivan uticaj odnosi se na omogućavanje korišćenja OIE u solarnoj elektrani, odnosno stvaranje preduslova za njeno priključenje na elektromrežu.	6, 7, 8, 9, 10	Manji negativni uticaji odnose se na period izgradnje, u kom može doći do privremenog narušavanja kvaliteta životne sredine. Takođe, očekuje se nejonizujuće zračenje na samom izvoru, ali ne postoji izloženost ljudi i objekata ovim uticajima.
⁝	⁝	⁝	⁝	⁝	⁝
n	...	...	...	...	...

Table 21. Illustrative Representation of the Identification of Strategically Significant and Other Impacts of Planning Solutions on the Environment.

Planning solutions	Identifying strategic impacts		Explanation	Smaller impacts on SES objectives	Explanation
	SEA objective	Rank			
Areas for electricity production in the solar power plant – SE zone	**9**	**N-2 / M / D**	The construction of the solar power plant will have a strong positive impact on increasing the use of renewable energy sources (RES) and improving the portfolio of the Republic of Serbia in this area. This strategically significant impact goes beyond the scope of the planning document and has national importance. Given the unexplored nature of the planning area in terms of immovable cultural heritage, it is theoretically possible that damage to such finds could occur during the works. However, this impact is conditional, as the plan includes measures for preventive protection, as well as the conduct of preliminary preventive archaeological investigations at the site	**1, 2, 3, 6, 4, 5**	Bearing in mind the results of biodiversity observations and the application of preventive protection principles in planning, only minor negative impacts on biodiversity and environmental factors are theoretically possible. These impacts are generally likely to occur during construction and are temporary in nature. On the other hand, the positive impacts relate to climate change and air quality
	12	**N+3 / S / D**			
Areas for agricultural activity – P and PZ zones	/	/	/	**7**	The use of chemicals in agriculture could have a negative impact on the soil quality at the location.
Areas for forest land – Š zone	/	/	/	**1, 2, 3, 7, 8**	The implementation of this planning solution will have positive impacts on biodiversity and the landscape

Planning solutions	Identifying strategic impacts		Explanation	Smaller impacts on SES objectives	Explanation
	SEA objective	Rank			
Area for the construction of the power complex serving the solar power plant (TS, PRP, -SkE) – EE zone	**12**	**N+3 / S / D**	The strategically significant positive impact relates to facilitating the use of renewable energy sources in a solar power plant, specifically creating the prerequisites for its connection to the electrical grid.	**6, 7, 8, 9, 10**	Minor negative impacts refer to the construction period during which there may be a temporary deterioration of environmental quality. Additionally, non-ionizing radiation is expected at the source, but there is no exposure of people or structures to these impacts.
⋮	⋮	⋮	⋮	⋮	⋮
n	...	...	...	...	...

Uočljivo je iz tabele 21 da planska rešenja iz Plana za kompleks solarne elektrane Brebeks mogu ostvariti i pozitivne i negativne strateški značajne uticaje na životnu sredinu i elemente održivog razvoja. Uočljivo je, međutim, i da pozitivni uticaji imaju veći rang u odnosu na identifikovane moguće negativne efekte realizacije Plana jer su oni samo teorijski mogući. Rezime uticaja planirane solarne elektrane na životnu sredinu dat je u nastavku.

It is evident from Table 21 that the planning solutions from the "Brebex" solar power complex Plan can have both positive and negative strategically significant impacts on the environment and elements of sustainable development. However, it is also noticeable that the positive impacts are ranked higher than the identified possible negative effects of the Plan's implementation because they are only theoretically possible. A summary of the impacts of the planned solar power plant on the environment is provided below.

5.3.2.3. Rezime uticaja na životnu sredinu

Rezimirajući uticaje planskih rešenja na ciljeve životne sredine, konstatovano je da će Plan imati dominantno pozitivne strateški značajne uticaje na ciljeve SPU.

Izgradnjom solarne elektrane ostvariće se pozitivan doprinos na smanjenje klimatskih promena i na poboljšanje portfolija Republike Srbije u oblasti korišćenja OIE, bez značajnih objektivnih strateški značajnih negativnih uticaja planskih rešenja na kvalitet životne sredine i ciljeve SPU.

Kao mogući negativni uticaji na planskom području izdvajaju se uticaji na osnovne činioce životne sredine kao posledica izvođenja radova na izgradnji solarne elektrane i objekata u funkciji njenog rada. Ovi uticaji nisu strateški značajni, ocenjeni su kao mali i prostorno i vremenski ograničeni, čime su ovi uticaji dodatno umanjeni.

U kontekstu mogućih uticaja projekta na biodiverzitet, mogu se izdvojiti zaključci koji slede.

5.3.2.3. Summary of Environmental Impacts

Summarising the impacts of planning solutions on environmental objectives, it has been noted that the Plan will have predominantly positive, strategically significant impacts on the objectives of the Spatial Plan for the Utility (SEA).

The construction of the solar power plant will make a positive contribution to reducing climate change and to improving the portfolio of the Republic of Serbia in the field of renewable energy use, without significant objectively significant negative impacts of planning solutions on the quality of the environment and the objectives of the SEA.

Possible negative impacts in the planning area include impacts on basic environmental factors as a result of the construction work on the solar power plant and facilities functioning in its operation. These impacts are not strategically significant, assessed as minor and spatially and temporally limited, which further mitigates these impacts.

In the context of possible impacts of the project on biodiversity, the following conclusions can be drawn.

Uticaj na staništa i floru

Analiza konflikata u odnosu na biodiverzitet sprovedena je u skladu s najvišim međunarodnim standardima i najboljom praksom u ovoj oblasti. Identifikovane su dve zone s generički zaštićenim vodenim/vlažnim staništima i nekoliko zona (u rubnim delovima lokacije) sa u izvesnoj meri očuvanim pa stoga i donekle konzervaciono vrednim šumskim staništima, gde može da se očekuje i prisustvo i najveća koncentracija konzervaciono vrednih vrsta flore i faune. Primenom principa preventivnog planiranja ove zone izuzete su iz prostora za realizaciju projekta, tj. u ovim zonama neće biti planirana projektna infrastruktura niti bilo koje aktivnosti na realizaciji projekta. Time su uništavanja i dodatna fragmentacija konzervaciono vrednih staništa, kao i gubitak staništa i moguće uništavanje/stradanje konzervaciono vrednih vrsta flore/faune, kao značajni štetni uticaji, pravovremeno sprečeni.

Od ostalih tipova staništa zastupljenih na lokaciji konzervacionu vrednost imaju još samo različiti tipovi suvih karbonatnih livada, ali samo kad su održavane tj. bar donekle očuvane. Ovakva staništa ne mogu da budu izložene značajnom štetnom uticaju projekta solarne elektrane, a njihova površina biće uvećana izgradnjom i održavanjem solarne elektrane. Uz primenu relativno jednostavnih mera upravljanja staništima (košenje i ispaša po odgovarajućoj dinamici, bez primene veštačkih đubriva i pesticida), kompatibilnih s radom projekta solarne elektrane, i kvalitet ovog tipa staništa na lokaciji može da se unapredi, što bi imalo značajan pozitivan uticaj na biodiverzitet, na šta ukazuju i Uslovi Zavoda za zaštitu prirode.

Impact on Habitats and Flora

The analysis of conflicts related to biodiversity was conducted in accordance with the highest international standards and best practices in this area. Two zones with generically protected aquatic/wetland habitats and several zones (on the periphery of the site) with somewhat preserved, and thus somewhat conservation-worthy, forest habitats have been identified, where the presence and highest concentration of conservation-worthy flora and fauna species can be expected. By applying the principle of preventive planning, these zones have been excluded from the project implementation area, i.e., no project infrastructure or any project implementation activities will be planned in these areas. Thus, the destruction and additional fragmentation of conservation-worthy habitats, as well as habitat loss and potential destruction/mortality of conservation-worthy species of flora/fauna, as significant adverse impacts, have been timely prevented.

Of the other types of habitats present at the location, only various types of dry calcareous grasslands have conservation value, but only when they are maintained or at least somewhat preserved. These habitats cannot be exposed to significant adverse impacts of the solar power plant project, and their area will be increased by the construction and maintenance of the solar power plant. With the application of relatively simple habitat management measures (mowing and grazing at appropriate intervals, without the use of artificial fertilizers and pesticides), compatible with the operation of the solar power plant project, the quality of this type of habitat on the site can be improved, which would have a significant positive impact on biodiversity, as indicated by the conditions set by the Nature Protection Institute.

Ostala staništa prisutna na lokaciji nemaju značajnu konzervacionu vrednost sama po sebi, pa ni direktni uticaji na njih ne mogu da budu značajni. To se u prvom redu odnosi na termofilne žbunjake, koji su rezultat sukcesije livada koje se više ne održavaju, a što je dominantan tip staništa na lokaciji. U sklopu izgradnje i rada solarne elektrane veći deo žbunaste vegetacije biće iskrčen, čime će se ova staništa vratiti u prethodno stanje, tj. konzervaciono vredne suve karbonatne livade. Ovo će imati pozitivan uticaj na biodiverzitet, pogotovo uz primenu odgovarajućih mera upravljanja staništima (očuvanje odnosno formiranje međa/živica i pojedinačnog žbunja u pojedinim delovima, uz održavanje livada na većini površine).

Staništa populacija konzervaciono vrednih vrsta flore identifikuju se i mapiraju u okviru ovog monitoringa. Primenom principa preventivnog planiranja i u skladu sa Uslovima Zavoda za zaštitu prirode, ove zone biće izuzete iz prostora za realizaciju projekta, tj. u ovim zonama neće biti planirana projektna infrastruktura niti bilo koje aktivnosti na realizaciji projekta. Time će uništavanje ovih konzervaciono vrednih populacija i njihovih staništa, kao mogući značajni štetni uticaji, biti potpuno i pravovremeno sprečeni. Štaviše, budući da su ovo najvećim delom vrste livadskih staništa, povećanje površine pod livadama moglo bi da ima pozitivan uticaj na populacije ovih vrsta, pogotovo uz primenu odgovarajućih mera upravljanja staništima navedenih gore.

Other habitats present at the location do not have significant conservation value in themselves, so direct impacts on them cannot be significant. This primarily refers to thermophilic shrubs resulting from the succession of meadows that are no longer maintained, which is the dominant type of habitat at the location. As part of the construction and operation of the solar power plant, most of the shrubby vegetation will be cleared, thereby returning these habitats to their previous state, i.e., conservation-worthy dry calcareous grasslands. This will have a positive impact on biodiversity, especially with the application of appropriate habitat management measures (preserving or forming hedgerows/hedges and individual shrubs in certain parts, while maintaining meadows on most of the surface).

Habitats of populations of conservation-worthy flora species are identified and mapped as part of this monitoring. By applying the principle of preventive planning, and in accordance with the conditions set by the Nature Protection Institute, these zones will be excluded from the project implementation area, i.e., no project infrastructure or any project implementation activities will be planned in these areas. This will completely and timely prevent the destruction of these conservation-worthy populations and their habitats, as potential significant adverse impacts. Moreover, since these are largely species of meadow habitats, increasing the area under meadows could have a positive impact on the populations of these species, especially with the application of appropriate habitat management measures mentioned above.

Uticaj na faunu (izuzev ornitofaune)

Primenom principa preventivnog planiranja, sva staništa koja imaju konzervacionu vrednost a mogla bi da budu izložena značajnim štetnim uticajima projekta (vodena/vlažna i šumska) izuzeta su iz prostora za realizaciju projekta. Time su i gubitak staništa i moguće slučajno/udesno stradanje najvećeg dela konzervaciono vrednih vrsta faune, kao mogući značajni štetni uticaji, pravovremeno sprečeni. Budući da su mnoge prisutne konzervaciono vredne vrste faune vezane za livadska staništa, povećanje površine pod livadama moglo bi da ima pozitivan uticaj na populacije ovih vrsta, pogotovo uz primenu odgovarajućih mera upravljanja staništima navedenih gore. Sprečeno je iole značajnije uznemiravanje a rizik od slučajnog/udesnog stradanja u skloništima sveden na minimum jer Uslovi Zavoda za zaštitu prirode propisuju da se radovi ne izvode tokom reproduktivnog perioda.

Impact on Fauna (excluding birdlife)

By applying the principle of preventive planning, all habitats with conservation value that could be exposed to significant adverse impacts of the project (aquatic/wet and forest habitats) have been excluded from the project implementation area. This has prevented habitat loss and the potential accidental casualty of the majority of conservation-worthy fauna species, as significant adverse impacts. Since many of the present conservation-worthy fauna species are associated with meadow habitats, increasing the area under meadows could positively impact these species' populations, especially with the application of appropriate habitat management measures mentioned earlier. Any significant disturbance has been prevented and the risk of accidental casualty in shelters is minimized because the conditions set by the Nature Protection Institute prescribe that works are not carried out during the reproductive period.

Uticaj na ornitofaunu

Ukupno 117 vrsta faune ptica zabeleženo je ili se smatra (potencijalno) prisutnim u obuhvatu planirane solarne elektrane i u neposrednoj okolini, od kojih većina u niskoj brojnosti. Od ovog broja, 109 vrsta koje aktivno koriste lokaciju odnosno neposrednu okolinu za gnežđenje odnosno ishranu mogle bi da budu izložene štetnim uticajima projekta, prevashodno gubitku/degradaciji staništa. Mogući uticaj gubitka/degradacije staništa, međutim, može eventualno da bude značajan samo za nekolicinu vrsta čije su konzervaciono vredne populacije prisutne na lokaciji. Uznemiravanje i slučajno/udesno stradanje

Impact on Birdlife

A total of 117 bird species have been recorded or are considered (potentially) present within the scope of the planned solar power plant and its immediate surroundings, most of which in low numbers. Of this number, 109 species that actively use the location and/or immediate surroundings for nesting and/or feeding could be exposed to the harmful impacts of the project, primarily habitat loss/degradation. However, the potential impact of habitat loss/degradation could be significant only for a few species whose conservation-worthy populations are present at the location. Disturbance and accidental casualty in nests are prevented u gnezdima sprečeno je jer Uslovi zaštite prirode propisuju da se radovi ne izvode tokom reproduktivnog perioda. Stradanje ptica usled sudara sa solarnim panelima ne može sasvim da se isključi, ali nije verovatno s fotonaponskim solarnim panelima koji su planirani projektom.

Primenom principa preventivnog planiranja sprečen je gubitak vodenih/vlažnih i šumskih staništa. Većina prisutnih vrsta faune ptica, uključujući i većinu čije su konzervaciono vredne populacije (potencijalno) prisutne na lokaciji, vezana je za mozaik žbunastih i travnih staništa. Izgradnja i rad projekta dovešće do povećanja površine pod livadama na račun sukcesivnih žbunjaka, ali uz očuvanje (i formiranje) međa/živica i pojedinačnog žbunja u pojedinim delovima, što znači da projekat ne može da dovede do gubitka staništa. Štaviše, primena odgovarajućih mera upravljanja staništima navedenih gore unapredilo bi kvalitet staništa na lokaciji za mnoge vrste ptica, što bi moglo da ima pozitivan uticaj na faunu ptica.

5.3.2.4. Određivanje kumulativnih i sinergijskih uticaja

U skladu sa Zakonom o strateškoj proceni uticaja na životnu sredinu (član 15), SPU obuhvata i procenu kumulativnih i sinergijskih efekata. Ovi efekti nastaju kao rezultat interakcije između brojnih manjih uticaja postojećih objekata i aktivnosti i različitih planiranih aktivnosti u području plana. Kumulativni efekti nastaju kad pojedinačna planska rešenja nemaju značajan uticaj, a nekoliko individualnih efekata zajedno mogu da imaju značajan efekat. Kao primer se

as the nature protection conditions prescribe that works are not performed during the reproductive period. Bird fatalities due to collisions with solar panels cannot be entirely ruled out, but they are unlikely with the photovoltaic solar panels planned for the project.

By applying the principle of preventive planning, the loss of aquatic/wet and forest habitats has been prevented. The majority of the present bird fauna species, including most whose conservation-worthy populations are (potentially) present at the location, are associated with a mosaic of shrub and grassland habitats. The construction and operation of the project will lead to an increase in the area under meadows at the expense of successive shrubs, but with the preservation (and formation) of hedgerows/hedges and individual shrubs in certain parts, meaning the project cannot lead to habitat loss. Moreover, the application of appropriate habitat management measures mentioned above would enhance the habitat quality at the location for many bird species, which could have a positive impact on bird fauna.

5.3.2.4. Determining Cumulative and Synergistic Impacts

In accordance with the Law on Strategic Environmental Assessment (Article 15), the SEA includes an assessment of cumulative and synergistic effects. These effects arise as a result of the interaction between numerous minor impacts of existing facilities and activities and various planned activities in the plan area. Cumulative effects occur when individual planning solutions do not have a significant impact, but several individual effects together can have a significant effect. Examples include može navesti zagađivanje vazduha, voda ili porast nivoa buke usled delovanja više pojedinačnih faktora (saobraćaj, industrija, individualna ložišta, itd.). Sinergijski efekti u interakciji pojedinačnih uticaja proizvode ukupni efekat koji je veći od prostog zbira pojedinačnih uticaja. Kumulativni i sinergijski efekti Plana već su jednim delom identifikovani u tabelama/matricama za višekriterijumsku evaluaciju (tabele 19 i 20), a delom se utvrđuju i prikazuju tabelarno po oblastima SPU, odnosno prema receptorima životne sredine (tabela 22).

pollution of air, water, or an increase in noise levels due to the action of multiple individual factors (traffic, industry, individual heating, etc.). Synergistic effects in the interaction of individual impacts produce a total effect that is greater than the mere sum of individual impacts. Cumulative and synergistic effects of the SEA have already been partly identified in the matrices for multi-criteria evaluation (Tables 19 and 20), and are partly determined and displayed per SEA areas, or according to environmental receptors (Table 22).

Tabela 22. Ilustrativni tabelarni prikaz pristupa u određivanju kumulativnih i sinergijskih efekata planskih rešenja s postojećim aktivnostima u planskom području

Table 22. Illustrative Table Display of the Approach in Determining Cumulative and Synergistic Effects of Planning Solutions with Existing Activities in the Planning Area

Interakcija prioritetnih aktivnosti Interaction of priority activities	Oblast SPU / SEA area
BIODIVERZITET / BIODIVERSITY	
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Negativne implikacije (obrazloženje) / Negative implications (explanation)*
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Pozitivni uticaji (obrazloženje) /Positive impacts (explanation)*
OSNOVNI ČINIOCI ŽIVOTNE SREDINE / BASIC FACTORS OF THE ENVIRONMENT	
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Negativne implikacije (obrazloženje) / Negative implications (explanation)*
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Pozitivni uticaji (obrazloženje) /Positive impacts (explanation)*
...	
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Negativne implikacije (obrazloženje) / Negative implications (explanation)*
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Pozitivni uticaji (obrazloženje) /Positive impacts (explanation)*
SOCIOEKONOMSKI RAZVOJ / SOCIO-ECONOMIC DEVELOPMENT	
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Negativne implikacije (obrazloženje) / Negative implications (explanation)*
Ciljevi SPU (1-n) / SEA objectives (1-n)	*Pozitivni uticaji (obrazloženje) /Positive impacts (explanation)*

5.4. Smernica za implementaciju plana

Završna faza u procesu izrade SPU za kompleks solarne elektrane Brebeks jeste definisanje smernica za implementaciju Plana u formi:

- smernica (mera) za zaštitu životne sredine,
- smernica za niže hijerarhijske nivoe planiranja i procene uticaja na životnu sredinu i
- smernica za praćenje stanja životne sredine (monitoring).

Ova faza sledi nakon evaluacije planskih rešenja i utvrđivanja posebno negativnih uticaja Plana na životnu sredinu. S obzirom na to da SPU nije instrument za direktno sprovođenje, već deo dokumentacione osnove plana, posebno je značajno da se smernice definisane u ovoj završnoj fazi izrade SPU inkorporiraju u tekst plana, jer se time obezbeđuje obaveza njihovog sprovođenja u toku implementacije plana.

U nastavku su okvirno i donekle uopšteno prikazane smernice koje su definisane u SPU za kompleks solarne elektrane Brebeks.

Smernice (mere) za zaštitu životne sredine

Zaštita životne sredine podrazumeva poštovanje svih opštih mera zaštite životne sredine i prirode i propisa utvrđenih zakonskom regulativom. U tom smislu se, na osnovu analiziranog stanja životne sredine u planskom području i njegovoj okolini i na osnovu procenjenih mogućih negativnih uticaja, definišu mere zaštite. Mere zaštite imaju za cilj da uticaje na životnu sredinu u okviru planskog područja svedu u okvire granica prihvatljivosti,

5.4. Guidelines for Plan Implementation

The final phase in the process of creating the SEA for the “Brebex” solar power complex is defining guidelines for the implementation of the Plan in the form of:

- Environmental protection measures (guidelines),
- Guidelines for lower hierarchical levels of planning and environmental impact assessments,
- Guidelines for environmental monitoring (monitoring).

This phase follows after the evaluation of planning solutions and the identification of particularly negative impacts of the Plan on the environment. Since the SEA is not a tool for direct implementation, but part of the Plan’s documentary base, it is particularly important that the guidelines defined in this final phase of the SEA are incorporated into the Plan text, as this ensures the obligation of their implementation during the Plan’s execution.

Below are the guidelines defined in the SEA for the “Brebex” solar power complex, presented in a broad and somewhat generalized manner.

Environmental Protection Measures

Environmental protection involves adhering to all general environmental and nature protection measures and regulations established by law. In this regard, based on the analysed state of the environment in the planning area and its surroundings and based on the assessed possible negative impacts, protective measures are defined. These measures aim to reduce impacts within the planning area to acceptable limits, with the goal of preventing a sa ciljem sprečavanja ugrožavanja životne sredine. One služe i da bi pozitivni uticaji zadržali takav trend. Mere zaštite omogućavaju razvoj i sprečavaju konflikte na datom prostoru, što je u funkciji realizacije ciljeva održivog razvoja.

U konkretnom slučaju, održivost osnovne planske namene uslovljena je očuvanjem i unapređenjem kvaliteta životne sredine u širem kontekstu, korišćenjem tzv. 'zelene energije.

Da bi pozitivni planski uticaji ostali u procenjenim okvirima koji neće opteretiti kapacitet prostora, a mogući negativni efekti planskih rešenja maksimalno se umanjili ili potpuno neutralisali, potrebno je sprovoditi mere za sprečavanje i ograničavanje negativnih uticaja Plana na životnu sredinu, odnosno za pojačavanje identifikovanih pozitivnih uticaja.

Na osnovu analize stanja životne sredine, prostornih odnosa planskog područja sa svojim okruženjem, planiranih aktivnosti u planskom području, procenjenih mogućih negativnih uticaja na kvalitet životne sredine i uslova nadležnih institucija, utvrđeno je preko 50 taksativno navedenih smernica (mera) zaštite. Mere zaštite grupisane su po oblastima SPU (biodiverzitet, osnovni činioci životne sredine, predeo, kulturno nasleđe, nejonizujuće zračenje).

Definisane smernice za zaštitu životne sredine bazirale su se na postornom aspektu zaštite životne sredine, ali su zbog specifičnosti planskog dokumenta kojim se predviđa izgradnja konkretnog projekta solarne elektrane (unapred je poznato mnogo tehničkih detalja o projektu), u ovom delu SPU definisane i smernice koje

environmental degradation. They also serve to maintain the positive impacts on this trend. Protective measures enable development and prevent conflicts in the given area, which is in function of achieving sustainable development goals.

In this specific case, the sustainability of the basic planning purpose is conditioned by the preservation and enhancement of environmental quality in a broader context, using so-called "green energy."

To ensure that the positive planning impacts remain within the estimated boundaries that will not burden the space's capacity, and that possible negative effects of planning solutions are minimized or completely neutralized, it is necessary to implement measures to prevent and limit the negative impacts of the plan on the environment, or to enhance the identified positive impacts.

Based on the analysis of the environmental state, spatial relationships of the planning area with its surroundings, planned activities in the planning area, assessed possible negative impacts on environmental quality, and conditions from competent institutions, over 50 explicitly listed protective measures (guidelines) have been determined. These protective measures are grouped by SEA areas (biodiversity, basic environmental factors, landscape, cultural heritage, non-ionizing radiation).

The defined guidelines for environmental protection were based on the spatial aspect of environmental protection, but due to the specifics of the planning document which predicts the construction of a specific solar power plant project (where many technical details about the project are already known), in this part of the SEA, guidelines that contain some technical elements sadrže neke tehničke elemente koji mogu uticati na projektna rešenja u fazi izrade tehničke dokumentacije.

S obzirom na to da je najveći doprinos SPU za Plan kompleksa solarne elektrane Brebeks ostvaren primenom principa preventivnog planiranja, smernice za zaštitu životne sredine neće imati značaj kao što bi to bilo u nekom drugačijem slučaju, gde nije primenjen ovako konzervativan pristup SPU.

Smernice za niže hijerarhijske nivoe planiranja i procene uticaja na životnu sredinu

Prema članu 16. Zakona o strateškoj proceni, Izveštaj o strateškoj proceni sadrži razrađene smernice za planove ili programe na nižim hijerarhijskim nivoima koje obuhvataju definisanje potrebe za izradom strateških procena i procena uticaja projekata na životnu sredinu, određuje aspekte zaštite životne sredine i druga pitanja od značaja za procenu uticaja na životnu sredinu planova i projekata nižeg hijerarhijskog nivoa.

U hijerarhiji prostornih/urbanističkih planova, Plan detaljne regulacije predstavlja najniži hijerarhijski nivo. Imajući u vidu ovu činjenicu, kao i činjenicu da se strateške procene uticaja na životnu sredinu izrađuju za prostorne i urbanističke planove, nije bilo osnova za davanje smernice za izradu strateških procena na nižim hijerarhijskim nivoima.

that can influence the project solutions in the phase of technical documentation preparation have also been defined.

Given that the greatest contribution of the SEA to the Plan of the “Brebex” solar power complex has been achieved through the application of the principle of preventive planning, the environmental protection guidelines will not be as significant as they might be in a different case, where such a conservative approach to the SEA has not been applied.

Guidelines for Lower Hierarchical Levels of Planning and Environmental Impact Assessments

According to Article 16 of the Law on Strategic Environmental Assessment, the Strategic Environmental Assessment Report contains detailed guidelines for plans or programs at lower hierarchical levels which cover defining the need for conducting strategic assessments and environmental impact assessments of projects. These guidelines determine aspects of environmental protection and other issues significant for the impact assessment of plans and projects at lower hierarchical levels.

In the hierarchy of spatial/urban planning, the detailed regulation plan is the lowest hierarchical level. Bearing this in mind, as well as the fact that strategic environmental impact assessments are prepared for spatial and urban plans, there was no basis for providing guidelines for conducting strategic assessments at lower hierarchical levels.

Shodno propozicijama i odredbama Zakona o proceni uticaja na životnu sredinu („Službeni glasnik RS"', broj 135/04 i 36/09), za potrebe pribavljanja građevinske dozvole za projekat solarne elektrane i prateće infrastrukture (pre svega trafostanice i priključnog dalekovoda) može se od strane nadležnog organa odlučivanja tražiti izrada Studije o proceni uticaja projekta na životnu sredinu kojom će se predvideti odgovarajuće tehničke i organizacione mere koje je potrebno sprovoditi u svim fazama realizacije projekta (tokom izgradnje, tokom eksploatacije, nakon eksploatacije), kako bi se prevenirale odnosno minimizirale moguće negativne implikacije projekta na životnu sredinu.

U tom kontekstu treba sagledati potrebu da se nosilac projekta (investitor), u skladu s članom 8. Zakona o proceni uticaja, obrati nadležnom organu za zaštitu životne sredine sa Zahtevom za odlučivanje o potrebi izrade Studije o proceni uticaja na životnu sredinu, u skladu sa Zakonom o zaštiti životne sredine („Službeni glasnik RS"', broj 135/04, 36/09, 72/09 – 43/11 – Ustavni sud, 14/2016, 76/2018, 95/2018 – dr. zakon i 95/2018 – dr. zakon), Zakonom o proceni uticaja na životnu sredinu („Službeni glasnik RS"', br. 135/04 i 36/09), Pravilnikom o sadržini studije o proceni uticaja na životnu sredinu („Službeni glasnik RS", br. 69/2005) i Uredbom o utvrđivanju Liste projekata za koje je obavezna procena uticaja i Liste projekata za koje se može zahtevati procena uticaja na životnu sredinu („Službeni glasnik RS", br. 114/08).

According to the propositions and provisions of the Environmental Impact Assessment Law ("Official Gazette of RS", numbers 135/04 and 36/09), for the purposes of obtaining a construction permit for the solar power plant project and associated infrastructure (primarily substations and connecting power lines), the competent decision-making authority may require the preparation of an Environmental Impact Assessment Study. This study should predict appropriate technical and organizational measures that need to be implemented in all phases of the project implementation (during construction, during operation, after operation) to prevent and/or minimize possible negative implications of the project on the environment.

In this context, it is necessary to consider the requirement for the project proponent (Investor) to approach the competent environmental protection authority with a Request for a decision on the need for an Environmental Impact Assessment Study, in accordance with the Environmental Protection Law ("Official Gazette of RS", numbers 135/04, 36/09, 72/09 – 43/11 – Constitutional Court, 14/2016, 76/2018, 95/2018 - other law and 95/2018 - other law), the Environmental Impact Assessment Law ("Official Gazette of RS", numbers 135/04 and 36/09), the Regulation on the content of the environmental impact assessment study ("Official Gazette of RS", number 69/2005), and the Regulation on determining the List of projects for which an impact assessment is mandatory and the List of projects for which an impact assessment may be required ("Official Gazette of RS", number 114/08).

Smernice koje je potrebno primeniti u toku dalje realizacije projekta jesu:

- očuvati prirodna staništa, živi svet i graditeljsko nasleđe;
- organizovati gradilište da ne dođe do zagađenja vazduha, vode i zemljišta tokom izvođenja radova;
- preduzeti mere za sprečavanje procurivanja ulja iz transformatora ukoliko se ne radi o suvim transformatorima;
- izraditi plan upravljanja otpadom od građenja i rušenja;
- nakon prestanka korišćenja solarne elektrane izvršiti uklanjanje svih objekata sa lokacije, a sa otpadnim materijalom postupati u skladu sa zakonom.

The guidelines that need to be applied during the further implementation of the project are:

- Preserve natural habitats, wildlife, and architectural heritage;
- Organise the construction site to prevent pollution of air, water, and soil during construction activities;
- Implement measures to prevent oil leaks from transformers unless they are dry-type transformers;
- Develop a waste management plan for construction and demolition debris;
- Upon decommissioning the solar power plant, remove all structures from the site and handle waste material in accordance with the law.

Smernica za praćenje stanja životne sredine (monitoring)

Specifičnost Plana za kompleks solarne elektrane Brebeks uslovila je specifičnost predloženog monitoringa. U tom kontekstu, sa aspekta zaštite životne sredine od posebnog značaja je praćenje sprovođenja smernica za zaštitu životne sredine u Planu i SPU, posebno u delu koji se odnosi na zaštitu biodiverziteta.

Predviđeno je da se monitoring osnovnih činilaca životne sredine i prirode sprovodi u skladu s relevantnom zakonskom regulativom. Sve navedene parametre potrebno je, u skladu sa institucionalnim nadležnostima, pratiti u odnosu na indikatore date prema receptorima životne sredine koji su definisani i prezentovani u tabeli 23 i u skladu sa zakonskim i podzakonskim aktima za određene aspekte životne sredine, a posebno u skladu sa Pravilnikom o Nacionalnoj listi indikatora zaštite životne sredine („Službeni glasnik RS”, br. 37/2011).

Guideline for Environmental Monitoring

The specifics of the Plan for the “Brebex” solar power complex necessitate a tailored monitoring approach. From an environmental protection perspective, monitoring the implementation of environmental protection guidelines within the Plan and SEA is of particular importance, especially in terms of biodiversity protection.

It is planned that the Monitoring of basic environmental and natural factors will be conducted in accordance with relevant legal regulations. All specified parameters need to be monitored, in line with institutional competencies, in relation to the indicators given for environmental receptors that are defined and presented in Table 23, and in accordance with legal and sub-legal acts pertaining to specific environmental aspects, particularly in line with the Regulation on the National List of Environmental Protection Indicators (“Official Gazette of the Republic of Serbia”, no. 37/2011).

Tabela 23. Indikatori za praćenje stanja **životne** sredine

Table 23. Environment condition monitoring indicators

Oblast monitoringa / Monitoring Area	Indikatori / Indicators
Biodiverzitet i staništa / Biodiversity and habitats	- Diverzitet vrsta / Species diversity *
Vazduh / Air	- Broj dana kada je prekoračena granična vrednost emisije za PM čestica, CO, SO_2 i NO_2 kao posledica izgradnje solarne elektrane / The number of days when the limit value for emissions of PM particles, CO, SO_2, and NO_2 is exceeded as a result of the construction of a solar power plant *
Klimatske promene / Climate change	- Doprinos promeni emisije GHG (CO_2, N_2O, CH_4, SF_6, HFC, PFC (%) *, kao rezultat izgradnje solarne elektrane / The contribution to the change in greenhouse gas emissions (CO_2, N_2O, CH_4, SF_6, HFC, PFC %), as a result of the construction of a solar power plant
Voda / Water	- Serbian Water Quality Index (SWQI)* - Emisije zagađujućih materija u vodna tela / Emissions of pollutants into water bodies * - Kvalitet vode za piće / Drinking water quality* - Biološka potrošnja kiseonika / Biological consumption of oxygen*
Zemljište / Soil	- % kontaminiranih površina / % contaminated surfaces - Promena načina korišćenja zemljišta / Change in land use*
Predeo / Landscape	- Broj i prostorna dispozicija planiranih solarnih panela / The number and spatial arrangement of planned solar panels - Izloženost/vidljivost lokacije / Exposure/visibility of the location
Kulturno nasleđe / Cultural heritage	- Broj potencijalno ugoženih lokaliteta na kojima postoje objekti kulturne baštine/arheološki ostaci / The number of potentially threatened sites where cultural heritage/archaeological remains exis
Nejonizujuće zračenje / Non-ionising radiation	- Izvori nejonizujućeg zračenja od posebnog interesa / Sources of non-ionising radiation of special interest* - Broj objekata koje mogu biti pod uticajem nejonizujućeg zračenja kao posledica realizacije projekta solarneelektrane / The number of facilities that may be affected by non-ionising radiation as a result of the implementation of the solar power plant project
Stanovništvo / Population	- Ukupni indikator buke / Total noise indicator*
Ekonomija i korišćenje OIE / Economy and use of RES	- Potrošnja primarne energije iz obnovljivih izvora / Primary energy consumption from renewable sources*

Kad su u pitanju obaveze Investitora, u cilju praćenja uticaja na biodiverzitet, predviđeno je da se po potrebi može sprovoditi:

- kontinuirani monitoring staništa, flore i faune (konstrukcijski monitoring), pri čemu je potrebno posebnu pažnju posvetiti strogo zaštićenim vrstama („Službeni glasnik RS", br. 5/2010, 32/2016, 98/2016). U slučaju utvrđivanja eventualnih činjenica o uticaju izgradnje solarne elektrane na prirodne vrednosti, dužnost i obaveza lica koja vrše opservacije bila bi da obaveste inicijatore i realizatore projekta, kao i nadležne institucije o nastaloj situaciji. Tako bi blagovremeno mogle da budu preduzete mere za otklanjanje i predupređivanje eventualnih posledica izgradnje solarne elektrane na biodiverzitet;
- **operativni / postkonstrukcijski monitoring**, kako bi se utvrdile činjenice o uticajima solarne elektrane na staništa, floru i pojedine grupe faune. Postkonstrukcijski monitoring treba naročito da obuhvati praćenje stanja staništa, populacija strogo zaštićenih, ugroženih i retkih vrsta flore i gnezdećih populacija ptica, a u skladu sa Uslovima zaštite prirode i važećom zakonskom regulativom, kao i aktuelnim naučnim znanjem i najboljom međunarodnom praksom u relevantnim oblastima.

Eventualna potreba i obim navedenih aktivnosti moraju biti iskazani u Rešenju o izdavanju uslova Zavoda za zaštitu prirode za potrebe izdavanja Lokacijskih uslova, zasnovano na rezultatima do tada sprovedenih opservacija biodiverziteta na lokaciji planirane solarne elektrane.

When it comes to the obligations of the Investor, for the purpose of monitoring the impact on biodiversity, it is envisaged that, if necessary, the following can be carried out:

- Continuous monitoring of habitats, flora, and fauna (structural monitoring), with special attention to be paid to strictly protected species ("Official Gazette of RS", No. 5/2010, 32/2016, 98/2016). In case any facts regarding the impact of the construction of the solar power plant on natural values are determined, the duty and obligation of the observing parties would be to inform the initiators and implementers of the project, as well as the competent authorities, about the situation. This would allow timely measures to be taken to mitigate and prevent any consequences of the construction of the solar power plant on biodiversity
- **Operational / post-construction monitoring** to establish facts about the impacts of the solar power plant on habitats, flora, and certain groups of fauna. Post-construction monitoring should particularly include monitoring the state of habitats, populations of strictly protected, endangered, and rare plant species, and nesting bird populations, in accordance with Nature Protection Conditions and applicable legal regulations, as well as current scientific knowledge and best international practice in relevant fields.

Any potential need and scope of the mentioned activities must be specified in the Decision on the issuance of conditions by the Institute for Nature Conservation for the purpose of issuing Location Conditions, based on the results of biodiversity observations conducted up to that point at the planned solar power plant location.

5.5. Zaključci SPU

Prepoznavši značaj zaštite životne sredine, pre svega biodiverziteta, koji može biti zahvaćen uticajem realizacije projekta solarne elektrane, investitor projekta *Sage Solutions d.o.o* iz Beograda inicijalno je, pre formalnih procedura koje označavaju početak postupka izade Plana angažovao ekspertski tim čiji je zadatak bio da izvrši opservacije biodiverziteta (flore, faune i staništa) na području na kom se planira realizacija projekta solarne elektrane Brebeks, čiji će rezultati biti inkorporirani u proces izrade SPU. Time se na samom početku razvoja projekta pristupilo primeni principa preventivne zaštite u SPU.

SPU je proces koji treba da integriše ciljeve i principe održivog razvoja u Plan. U toku postupka SPU za kompleks solarne elektrane Brebeks, analizirano je postojeće stanje životne sredine, značaj i karakteristike Plana, karakteristike uticaja planiranih rešenja i druga pitanja i problemi zaštite životne sredine u skladu s kriterijumima za određivanje mogućih uticaja na životnu sredinu. U tom procesu dominantno je primenjen planerski pristup koji sagledava trendove koji mogu nastati u prostoru kao rezultat (pozitivni uticaji) odnosno posledica (negativni uticaji) planiranih aktivnosti.

U izradi SPU primenjen je metodološki pristup baziran na definisanju ciljeva i indikatora održivog razvoja i višekriterijumskoj kvalitativnoj evaluaciji planiranih rešenja u odnosu na definisane ciljeve SPU i pripadajuće indikatore. U okviru SPU definisano je 12 ciljeva i 20 pripadajućih indikatora za ocenu planskih rešenja. U proces višekriterijumskog

5.5. SEA conclusions

Recognising the importance of environmental protection, particularly biodiversity, which may be affected by the implementation of a solar power plant project, the investor of the Brebex solar power plant project, *Sage Solutions* from Belgrade, initially, prior to formal procedures marking the beginning of the Strategic Environmental Assessment (SEA) drafting process, engaged an expert team tasked with conducting observations of biodiversity (flora, fauna, and habitats) in the area where the implementation of the Brebex solar power plant project is planned. The results of these observations will be incorporated into the SEA drafting process. Thus, at the very beginning of the project development, a preventive protection approach was adopted in the SEA.

The SEA is a process aimed at integrating the goals and principles of sustainable development into the Plan. During the SEA process for the Brebex solar power plant complex, the existing state of the environment, the significance and characteristics of the plan, the characteristics of the impacts of planned solutions, and other environmental protection issues and problems were analysed in accordance with the criteria for determining possible environmental impacts. In this process, a planning approach dominated, which considers the trends that may arise in the area as a result (positive impacts) and/or consequences (negative impacts) of planned activities.

The SEA drafting employed a methodological approach based on defining the goals and indicators of sustainable development and multi-criteria qualitative evaluation of planned solutions in relation to the defined SEA goals and corresponding indicators. Within the SEA, 12 goals and 20 corresponding indicators were defined for the assessment of planning solutions. The process of multi-criteria evaluation vrednovanja uključeno je 8 planskih rešenja koja su definisana PDR-om, a koja su značajna sa aspekta zaštite životne sredine. Ova planska rešenja vrednovana su po osnovu sledećih grupa kriterijuma:

- veličine uticaja,
- prostornih razmera mogućih uticaja,
- verovatnoće uticaja i
- učestalosti uticaja.

Formirane su matrice u kojima je izvršena višekriterijumska evaluacija i na taj način su dobijeni rezultati prikazani grafikonima na jednostavan i razumljiv način, a rezultati vrednovanja ukazali su na činjenicu da implementacija Plana ne implicira strateški značajne negativne uticaje na ciljeve SPU (osim teorijski mogućih uticaja na kulturno nasleđe, za šta su Planom i SPU predviđene preventivne mere zaštite), a da će se određeni negativni uticaji, koji se dominantno mogu implicirati u fazi izgradnje solarne elektrane, minizirati ili potpuno eliminisati odgovornom realizacijom projekta, odnosno projektovanjem i odgovarajućom organizacijom tokom faze izgradnje. To je posebno moguće u kontekstu zaštite osnovnih činilaca životne sredine i biodiverziteta.

S druge strane, identifikovan je čitav niz pozitivnih uticaja planskih rešenja. Izgradnjom solarne elektrane ostvariće se jak pozitivni uticaj na smanjenje klimatskih promena i na uslove za korišćenje OIE, bez značajnih strateški negativnih uticaja na kvalitet životne sredine i ciljeve SPU. Ovakvim rezultatima su posebno doprineli rezultati kontinuiranih opservacija biodiverziteta koje su sprovedene na lokaciji planirane solarne elektrane.

included 8 planning solutions defined by the Preliminary Design Report (PDR), which are significant from the perspective of environmental protection. These planning solutions were evaluated based on the following groups of criteria:

- Magnitude of impacts,
- Spatial extent of potential impacts,
- Probability of impacts, and
- Frequency of impacts.

Matrices were formed in which a multi-criteria evaluation was conducted, and in this way, the results were presented through graphs in a simple and understandable manner. The evaluation results indicated that the implementation of the Plan does not imply strategically significant negative impacts on the SEA objectives (except for theoretically possible impacts on cultural heritage for which preventive protection measures are provided by the Plan and SEA), and that certain negative impacts, which can predominantly occur during the construction phase of the solar power plant, will be minimized or completely eliminated through responsible project implementation, i.e., through project design and appropriate organization during the construction phase. This is especially possible in the context of protecting the basic environmental factors and biodiversity.

On the other hand, a whole range of positive impacts of planning solutions has been identified. The construction of the solar power plant will have a strong positive impact on reducing climate change and on the conditions for the use of RES, without significant strategically negative impacts on environmental quality and SEA objectives. These results were particularly contributed by the continuous biodiversity observations conducted at the location of the planned solar power plant. Planning solutions were aligned with the results of

Planska rešenja usklađivala su se sa rezultatima izvršenih opservacija, čime je ostvaren princip preventivne zaštite u planskom procesu.

Shodno propozicijama i odredbama Zakona o proceni uticaja na životnu sredinu („Službeni glasnik RS", broj 135/04 i 36/09), za potrebe pribavljanja građevinske dozvole za projekat solarne elektrane i prateće infrastrukture (pre svega trafostanice, PRP i priključnog dalekovoda) može se tražiti izrada Studije o proceni uticaja projekta na životnu sredinu, kojom će se predvideti odgovarajuće tehničke i organizacione mere koje je potrebno sprovoditi u svim fazama realizacije projekta (tokom izgradnje, tokom eksploatacije, nakon eksploatacije), kako bi se prevenirale odnosno minimizirale moguće negativne implikacije projekta na životnu sredinu. U tom kontekstu, investitor je u skladu s članom 8. Zakona o proceni uticaja u obavezi da se za priključne objekte na elektromrežu (trafostanica, PRP, dalekovod) obrati nadležnom organu za zaštitu životne sredine sa Zahtevom za odlučivanje o potrebi izrade Studije o proceni uticaja na životnu sredinu, u skladu sa Zakonom o zaštiti životne sredine („Službeni glasnik RS", broj 135/04, 36/09, 72/09 – 43/11 – Ustavni sud, 14/2016, 76/2018, 95/2018 – dr. zakon i 95/2018 – dr. zakon), Zakonom o proceni uticaja na životnu sredinu („Službeni glasnik RS", br. 135/04 i 36/09), Pravilnikom o sadržini studije o proceni uticaja na životnu sredinu („Službeni glasnik RS", br. 69/2005) i Uredbom o utvrđivanju Liste projekata za koje je obavezna procena uticaja i Liste projekata za koje se može zahtevati procena uticaja na životnu sredinu („Službeni glasnik RS", br. 114/08).

these observations, thus achieving the principle of preventive protection in the planning process.

In accordance with the provisions of the Law on Environmental Impact Assessment ("Official Gazette of RS", No. 135/04 and 36/09), for the purpose of obtaining a construction permit for the solar power plant project and accompanying infrastructure (primarily substations, grid connection points, and connecting transmission lines), an Environmental Impact Assessment (EIA) Study may be required. This study would predict the appropriate technical and organizational measures to be implemented in all phases of the project implementation (during construction, during operation, after operation) to prevent and/or minimize possible negative project implications on the environment. In this context, the Investor is obliged, in accordance with Article 8 of the Law on Environmental Impact Assessment, to address the competent environmental protection authority with a Request for a decision on the need to prepare an Environmental Impact Assessment Study for connecting facilities to the power grid (substations, grid connection points, transmission lines), in accordance with the Law on Environmental Protection ("Official Gazette of RS", No. 135/04, 36/09, 72/09 – 43/11 – Constitutional Court, 14/2016, 76/2018, 95/2018 - other law, and 95/2018 - other law), the Law on Environmental Impact Assessment ("Official Gazette of RS", No. 135/04 and 36/09), the Regulation on the Content of the Environmental Impact Assessment Study ("Official Gazette of RS", No. 69/2005), and the Regulation on Determining the List of Projects for which Environmental Impact Assessment is Mandatory and the List of Projects for which Environmental Impact Assessment may be required ("Official Gazette of RS", No. 114/08).

Iako su identifikovani negativni uticaji dominantno privremenog i lokalnog karaktera i odnose se prevashodno na intervencije u toku realizacije/izgradnje projekta na određenim mikrolokalitetima i na rad mehanizacije koja će se koristi za izgradnju, u SPU su definisane mere za predupređenje odnosno minimizaciju mogućih negativnih uticaja na životnu sredinu na ciljeve SPU, smernice za izradu tehničke dokumentacije i program praćenja stanja životne sredine (monitoring). Sprovođenje propozicija SPU formulisanih u okviru navedenih oblasti SPU trebalo bi da osigura održivu realizaciju projekta u skladu s principima preventivne i aktivne zaštite životne sredine.

Imajući u vidu karakteristike, verovatnoću i prostornu disperziju mogućih uticaja planskih rešenja na životnu sredinu, kao i smernice za zaštitu životne sredine, zaključeno je da Plan i SPU daju rešenja koja su dobra pretpostavka za zaštitu životne sredine i održivo korišćenje prostora na planskom području. Donošenjem Plana obezbediće se korišćenje tzv. zelene energije i time uticati na poboljšanje portfolija Republike Srbije u oblasti korišćenja OIE. U tom kontekstu može se smatrati da će realizacija projekta elektrane Brebeks, pored pozitivnog lokalnog imati i pozitivan nacionalni značaj. Zbog toga je ocenjeno da se Plan po osnovu uticaja na životnu sredinu može smatrati u celosti prihvatljivim, a njegova dalja razrada, u kontekstu zaštite životne sredine, sprovešće se kroz izradu tehničke dokumentacije, u skladu s propozicijama relevantne legislative.

Although the identified negative impacts are predominantly temporary and local in nature, primarily related to interventions during the implementation/construction phase of the project at specific micro-sites and the operation of machinery used for construction, measures for prevention and/or minimization of possible negative environmental impacts on SEA objectives have been defined in the SEA. Guidelines for the preparation of technical documentation and environmental monitoring programs have also been included. Implementation of the SEA provisions formulated within these areas should ensure sustainable project implementation in accordance with the principles of preventive and active environmental protection.

Considering the characteristics, probability, and spatial dispersion of potential impacts of planning solutions on the environment, as well as environmental protection guidelines, it has been concluded that the Plan and SEA provide solutions that are a good basis for environmental protection and sustainable land use in the planning area. By adopting the Plan, the use of so-called “green energy” will be ensured, thereby influencing the improvement of the Republic of Serbia’s portfolio in the field of RES utilization. In this context, it can be considered that the implementation of the “Brebex” power plant project, in addition to its positive local impact, will also have positive national significance. Therefore, it has been assessed that the Plan can be considered entirely acceptable based on its environmental impact, and its further development, in the context of environmental protection, will be carried out through the preparation of technical documentation, in accordance with the provisions of relevant legislation.

6. DISKUSIJA I ZAKLJUČCI

Globalni trend smanjenja ugljeničnog otiska evidentno je doprineo razvoju sektora energetike koji se bazira na korišćenju OIE, u okviru kog sektor solarne energetike poslednjih godina predstavlja jedan od najbrže rastućih sektora. Postoji nekoliko razloga za ovakav trend razvoja u oblasti korišćenja OIE:

- projekti koji koriste OIE imaju vrlo važnu ulogu u smanjenju emisije gasova sa efektom staklene bašte u oblasti energetike jer se njima zamenjuje ista količina energije koju bi trebalo proizvesti u elektranama na fosilno gorivo;
- povećanje udela OIE povećava energetsku održivost sistema i daje doprinos u smanjenju zavisnosti od uvoza energetskih sirovina i električne energije;
- smanjenjem cene opreme koja se ugrađuje u projekte koji koriste OIE oni postaju ekonomski konkurentniji konvencionalnim izvorima energije, s jedne strane, i privlačniji investitorima, s druge strane;
- projekti koji koriste OIE u skladu su sa aktuelnim trendom osvešćivanja javnosti o ekološkim pitanjima.

Kad je reč o razvoju projekata koji koriste sunčevu (solarnu) energiju ili tzv. zelenu energiju, može se konstatovati da ovi projekti, kao i svi drugi projekti, mogu imati i pozitivne i negativne uticaje na prostor i životnu sredinu.

Sagledavanje pozitivnih uticaja solarnih elektrana mora se staviti u širi kontekst koji prevazilazi okvire pojedinačnih projekata,

6. DISCUSSION AND CONCLUSIONS

The global trend of reducing the "carbon footprint" has evidently contributed to the development of the energy sector based on the utilization of renewable energy sources (RES), in which the solar energy sector has emerged as one of the fastest-growing sectors in recent years. There are several reasons for this trend in the development of RES utilization:

- Projects using RES play a crucial role in reducing greenhouse gas emissions in the energy sector by replacing the same amount of energy that would otherwise be produced in fossil fuel power plants;
- Increasing the share of RES enhances the energy sustainability of the system and contributes to reducing dependence on the import of energy resources and electricity;
- By reducing the cost of equipment installed in RES projects, they become economically more competitive than conventional energy sources on one hand, and more attractive to investors on the other;
- Projects using RES align with the current trend of raising public awareness about environmental issues.

When it comes to the development of projects using solar energy or so-called "green energy," it can be observed that these projects, like all other projects, can have both positive and negative impacts on the environment and space.

Assessing the positive impacts of solar power plants must be placed in a broader pa čak i regionalnih i nacionalnih razvojnih projekata u oblasti energetike. U tom kontekstu pozitivni uticaji odnose se na dva ključna aspekta:

1. **smanjenje emisije zagađujućih materija u vazduh** – Proizvodnja električne energije u solarnim elektranama isključuje emisije u vazduh, što indirektno povoljno utiče na zdravlje stanovništva, biodiverzitet i druge elemente životne sredine. Dodatni doprinos se ostvaruje zbog toga što razvoj solarne energetike u perspektivi dovodi do smanjenja upotrebe elektrana koje koriste fosilna goriva, čiji su negativni uticaji na kvalitet životne sredine višestruki; i
2. **klimatske promene** – Dobijanje električne energije iz energije sunca u solarnim elektranama ne proizvodi gasove sa efektom staklene bašte i potencijalno je važan korak ka „stabilizaciji" klime. Dakle, pozitivan uticaj na usporavanje klimatskih promena još jedan je bitan i pozitivan uticaj solarnih elektrana, pogotovo kad se kombinuje s proporcionalnim zatvaranjem elektrana koje koriste fosilna goriva.

Što se tiče mogućih negativnih uticaja solarnih elektrana na prostor i životnu sredinu, one mogu implicirati različite negativne uticaje u zavisnosti od veličine projekta i specifičnosti lokacije na kojoj se planira njihova realizacija. Dominantni negativni uticaji odnose se na:

- zauzimanje velikih površina zemljišta,
- biodiverzitet,
- predeo.

Razmera mogućih uticaja zavisi od konkretnih uslova na mikrolokacijskom nivou, zbog čega je u fazi izbora lokacije za solarnu elektranu, izrade planskog

context that transcends the framework of individual projects, even regional and national development projects in the energy sector. In this context, the positive impacts relate to two key aspects:

1. **Reduction of air pollutants emissions -** because the production of electricity in solar power plants excludes emissions into the air, which indirectly benefits public health, biodiversity, and other elements of the environment. An additional contribution is made because the development of solar energy ultimately leads to a reduction in the use of power plants that use fossil fuels, whose negative impact on environmental quality is manifold, and
2. **Climate change** - obtaining electricity using solar energy in solar power plants does not produce greenhouse gases and potentially represents an important step towards "stabilizing" the climate. Therefore, the positive impact on slowing climate change is another important and positive aspect of solar power plants, especially when combined with the proportional closure of power plants using fossil fuels..

As for the potential negative impacts of solar power plants on the environment and space, they can imply various adverse effects depending on the size of the project and the specificities of the location where their implementation is planned. The dominant negative impacts include:

- occupying large areas of land,
- biodiversity,
- landscape.

The scale of potential impacts depends on the specific conditions at the micro-location level, which is why, in the phase dokumenta i SPU potrebno primeniti princip preventivne zaštite. Prilikom utvrđivanja razmera mogućih negativnih uticaja solarnih elektrana na životnu sredinu, međutim, uvek treba imati u vidu koristiod realizacije ovakvih projekata u poređenju sa uticajima nekih drugih elektrana (posebno onih koje rade na fosilna goriva). Tako izvršena komparativna analiza upućuje na zaključak da su i određeni negativni uticaji solarnih elektrana na životnu sredinu relativni, jer ipak, u širem kontekstu, dovode do određenih pozitivnih trendova u životnoj sredini i energetici. Pored toga, prevazilaženje potencijalnih negativnih uticaja solarne elektrane moguće je, pored primena principa preventivne zaštite, primenom mera aktivne planske zaštite, koja se ogleda u realizaciji koncepta agrosolarne elektrane ili npr. primenom koncepta tzv. solarnih pejzaža ili optimalnom prostornom raspodelom projekata solarnih elektrana na nacionalnom ili regionalnom nivou i drugim planskim merama za umanjenje mogućih uticaja.

Kad govorimo o instrumentima kojima se utvrđuju mogući uticaji solarnih elektrana na životnu sredinu, izdvajaju se dva instrumenta koja imaju globalnu upotrebu. To su SPU i PU. Karakteristika oba instrumenta jeste primena holističkog pristupa u sagledavanju interakcija postojećih i planiranih aktivnosti na određenom prostoru. Bitna razlika u pristupu proceni uticaja na životnu sredinu uslovljena je vrstom dokumenata za koju se radi, odnosno fazi razvoja projekta u kojoj se primenjuje. S tim u vezi, SPU se primenjuje na strateškom nivou planiranja, dok se PU primenjuje na nivou konkretnih investicionih projekata, odnosno na nivou tehničke dokumentacije. U tom kontekstu,

of site selection for a solar power plant, creating planning documents, and the SEA, it is necessary to apply the principle of preventive protection. However, when determining the scale of possible negative impacts of solar power plants on the environment, one should always consider the benefits of implementing such projects compared to the impacts of other types of power plants (especially those that operate on the principle of using fossil fuels). Such comparative analysis leads to the conclusion that the negative impacts of solar power plants on the environment are relative because, in a broader context, they lead to certain positive trends in the environment and energy sector. Moreover, overcoming potential negative impacts of a solar power plant is possible, in addition to applying the principle of preventive protection, by implementing measures of active planning protection which includes realizing the concept of agrosolar power plants, or, for example, implementing the concept of so-called solar landscapes, or the optimal spatial distribution of solar power plant projects at the national or regional level and other planning measures to mitigate possible impacts.

Regarding the instruments that determine the possible impacts of solar power plants on the environment, two instruments are globally used. These are SEA and EIA. A characteristic of both instruments is the application of a holistic approach in considering the interactions of existing and planned activities in a given area. A significant difference in the approach to environmental impact assessment is conditioned by the type of documents they are created for, or the phase of project development in which they are applied. In this context, the SEA is applied at the strategic

SPU se nameće kao instrument u kom je, pored primene holističkog pristupa u sagledavanju interakcija postojećih i planiranih namena na određenom prostoru moguće primeniti princip preventivne zaštite u najranijoj fazi razvoja projekta solarne elektrane. Tako je moguće predupservisi sve potencijalne rizike koji mogu nastati u kasnijim fazama realizacije projekta, što je i iz ugla investitora koji ulažu u projekte solarnih elektrana od posebnog značaja.

Primena SPU u metodološkom i proceduralnom smislu uslovljena je vrstom planskog dokumenta uz koji se sprovodi postupak SPU (strateški dokumenti nacionalnog ili regionalnog nivoa – kada SPU ostvaruje svoj pun potencijal ili lokalni razvojni planski dokument – kada je SPU ograničena na manje kompleksan prostor).

Na ovom mestu posebno je značajno naglasiti da primena SPU za projekte solarnih elektrana ne isključuje primenu PU, već prvi (i najvažniji) korak u kontinuiranim predikcijama mogućih uticaja solarnih elektrana na životnu sredinu koji prethodi izradi PU u kasnijim fazama razvoja projekta, odnosno tokom izrade tehničke dokumentacije.

Primena SPU u planiranju solarnih elektrana bazira se na smernicama za izbor optimalnih opcija za minimiziranje ili potpuno sprečavanje potencijalnih konflikata u prostoru, koji mogu nastati u korelaciji solarne elektrane sa elementima životne sredine. Optimalne opcije traže se prvenstveno u analizi prostornih odnosa solarne elektrane prema zemljištu, biodiverzitetu, predelu i osnovnim činiocima životne sredine. Kako je u knjizi

planning level, while the EIA is applied at the level of specific investment projects, or at the level of technical documentation. In this context, the SEA emerges as an instrument where, in addition to applying a holistic approach in considering the interactions of existing and planned uses in a specific area, it is possible to apply the principle of preventive protection at the earliest stage of the solar power plant project development. Thus, it is possible to prevent all potential risks that may arise in later stages of the project's realization, which is of particular importance from the perspective of investors investing in solar power plant projects..

The application of SEA in a methodological and procedural sense is conditioned by the type of planning document with which the SEA process is conducted (strategic documents at national or regional levels – where SEA achieves its full potential, or local development planning documents – where SEA is limited to a less complex space).

It is particularly important to emphasize that the application of SEA for solar power plant projects does not exclude the application of EIA, but rather represents the first (and most important) step in continuous predictions of possible impacts of solar power plants on the environment, which precedes the creation of EIA in later phases of project development, during the preparation of technical documentation.

The application of SEA in planning solar power plants is based on guidelines for choosing optimal options to minimize or completely prevent potential conflicts in space that may arise in correlation with the solar power plant and environmental elements. Optimal options are primarily sought in the analysis of spatial relations prikazano, ovaj proces se, u metodološkom smislu, ostvaruje kombinacijom različitih metodoloških pristupa i metoda za procenu uticaja, kao deo jedinstvenog semi-kvantitativnog metoda višekriterijumske evaluacije planskih rešenja. To jednim delom podrazumeva kombinaciju tehničkog pristupa (karakterističnog za PU) i planerskog pristupa (karakterističnog za SPU).

Primena semikvantitativnog metoda višekriterijumske ekspertske evaluacije u planiranju solarne elektrane prikazana je u knjizi na konkretnom primeru primene SPU za kompleks solarne elektrane Brebeks. Rezultati primene ovog metoda procene uticaja bili su u funkciji podrške u donošenju odluka o prostornom razvoju solarne elektrane na konkretnom prostoru. Time je ostvarena aplikativnost teorijskih saznanja.

Na osnovu teorijskih postavki i konkretnog rezultata primenjenog metoda na studiji slučaja kompleksa solarne elektrane Brebeks, koji je prikazan u drugom (aplikativnom) delu knjige, zaključuje se da je semikvantitativni metod višekriterijumske ekspertske evaluacije pogodna podrška u proceni uticaja solarne elektrane u SPU, preventivnoj zaštiti životne sredine na području na kom se planira izgradnja solarne elektrane; iprocesu donošenja optimalnih odluka o prostornom razvoju.

Negativan kontekst primene SPU u odnosu na iznete stavove može biti dvojaka: 1) u proceni uticaja onih elemenata u SPU koji se baziraju na subjektivnosti ekspertskih stavova i 2) u donošenju odluka na osnovu rezultata SPU jer ne zavisi uvek od kvaliteta rezultata SPU, već i od stavova i

of the solar power plant towards the land, biodiversity, landscape, and basic environmental factors. As shown in the book, this process is methodologically realized through a combination of different methodological approaches and methods for impact assessment, as part of a unique semiquantitative method of multi-criteria evaluation of planning solutions. This partly involves a combination of technical (characteristic of EIA) and planning (characteristic of SEA) approaches.

The application of the semiquantitative multi-criteria expert evaluation method in planning the solar power plant is demonstrated in the book through a specific example of SEA application for the solar complex “Brebex”. The results of applying this impact assessment method were functional in supporting decision-making about the spatial development of the solar power plant in the specific area. This achieved the applicability of theoretical knowledge.

Based on theoretical premises and the specific result of the applied method in the case study of the “Brebex” solar complex shown in the second (applied) part of the book, it is concluded that the semiquantitative multi-criteria expert evaluation method is a suitable support in: assessing the impact of the solar power plant in SEA; preventive environmental protection in the area where the construction of the solar power plant is planned; the process of making optimal decisions about spatial development.

The negative context of applying SEA in relation to the points made can be twofold: 1. in assessing the impact of those elements in SEA that are based on the subjectivity of expert opinions, and 2. in decision-making based on SEA results because it does not znanja donosilaca odluka. Dakle, u oba slučaja figurira termin subjektivnost pa je makar u procesu SPU potrebno postizanje maksimalne moguće objektivnosti primenom raspoloživih tehnika (softverski i matematički modeli), dok se na subjektivnosti u donošenju odluka na osnovu rezultata SPU može uticati samo edukacijom donosilaca odluka.

always depend on the quality of SEA results, but also on the opinions and knowledge of decision-makers. Thus, in both cases, the term "subjectivity" appears, and at least in the SEA process, achieving the maximum possible objectivity through available techniques (software and mathematical models) is necessary, while subjectivity in decision-making based on SEA results can only be influenced by educating decision-makers.

LITERATURA / REFFERENCES

Adhikari S, Mithulananthan N, Dutta A, Mathias A.J. (2008). Potential of sustainable energy technologies under CDM in Thailand: Opportunities and barriers. Renewable Energy Volume 33, Issue 9, 2122–2133. https://doi.org/10.1016/j.renene.2007.12.017

Ananda J, Heralth G. (2009). A critical review of multi-criteria decision-making methods with special reference to forest management and planning. Ecological Economics, Vol 68 (10), pp. 2535–2548. https://doi.org/10.1016/j.ecolecon.2009.05.010.

Bennun L, van Bochove J, Ng C, Fletcher C, Wilson D, Phair N, Carbone G. (2021). Mitigating biodiversity impacts associated with solar and wind energy development: guidelines for project developers. IUCN Publication. ISBN: 978-2-8317-2101-9. https://doi.org/10.2305/IUCN.CH.2021.04.en.

Brown AL, Therivel R. (2000). Principles to guide the development of strategic environmental assessment. Impact Assessment and Project Appraisal, Volume 18, Issue 3. pp. 183–189. https://doi.org/10.3152/147154600781767385.

Campo A.G.D. (2017). Mapping environmental sensitivity: A systematic online approach to support environmental assessment and planning. Environmental Impact Assessment Review, Volume 66. Pages 86–98. https://doi.org/10.1016/j.eiar.2017.06.010.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

CEC (1984a), European Solar Radiation Atlas, Vol. I Horizontal Surfaces. Commission of the European Communities, (Gburčik, V. saradnik za područje Jugoslavije).

CEC (1984b), European Solar Radiation Atlas,- Vol. II Inclined Surfaces. Commission of the European Communities, (Gburčik, V. saradnik za područje Jugoslavije).

CEC (2000a), The European Solar Radiation Atlas, Vol. I Fundamentals and maps. Commission of the European Communities CEC (2000b).

Chaker A, El-Fadl K, Chamas L, Hatjian B. (2006). A review of strategic environmental assessment in 12 selected countries. Environmental Impact Assessment Review, Volume 26, Issue 1, pp. 15–56. https://doi.org/10.1016/j.eiar.2004.09.010.

Crnčević T, Marić I, Josimović B. (2011). Strategic Environmental Assessment and Climate Change in the Republic of Serbia – Support to Development and Adjustment Process. SPATIUM No 26, IAUS, Belgrade, pp. 14–19. https://doi.org/10.2298/SPAT1126014C.

Dalal-Clayton B, Sadler, B. (2005). Strategic environmental assessment: a sourcebook and reference guide to international experience. OECD, UNEP and IIED in association with Earthscan Publications.

Depuydt L. (1998). Gnomons at Meroë and Early Trigonometry. The Journal of Egyptian Archaeology, Vol. 84, pp. 171–180 (10 pages). https://doi.org/10.2307/3822211.

Direktiva br. 2001/77/EC Evropskog parlamenta i Saveta od 27. septembra, 2002. godine, o promociji električne energije proizvedene iz obnovljivih izvora energije.

Direktiva br. 2009/28/EC Evropskog parlamenta i Saveta od 23. aprila, 2009. godine, o promociji upotrebe energije iz obnovljivih izvora.

Direktiva br. 2018/2001/EC o promicanju uporabe energije iz obnovljivih izvora.

Dobričić M, Josimović B. (2018). Sinergija prirodnog i kulturnog nasleđa (Synergy of Natural and Cultural Heritage). Arhitektura i urbanizam, 46, 39–45. https://doi.org/10.5937/a-u0-16268.

Dobričić M, Kesić Ristić S, Josimović B. (2016). The spatial planning, protection and management of world heritage in Serbia. Spatium Vol. 2016, No 36. https://doi.org/10.2298/SPAT1636075D.

Dobričić M, Sekulić N, Josimović B. (2017). Spatial planning and ecological networks in Serbia. Spatium 38, 18–26. https://doi.org/10.2298/SPAT1738018D.

Doing Business, 2020. http://www.doingbusiness.org/.

EIA Directive (85/337/EEC). http://ec.europa.eu/environment/eia/eia-legalcontext.htm.

Ember (2023), Globalna studija o potrošnji električne energije. https://ember-climate.org

Energy Saving Company – ESCO (2017). www.esco.rs.

European Strategic Environmental Assessment Directive 2001/42/ EC.

European Landscape Convention (2000). Council of Europe, Florence.

Fischer T. (2002). Strategic Environmental Assessment in Transport and Land Use Planning, Earthscan Publications, London. ISBN 9781853838118.

García-Ayllón S. (2017). Diagnosis of complex coastal ecological systems: Environmental GIS analysis of a highly stressed Mediterranean lagoon through spatiotemporal indicators. Ecological Indicators, Volume 83. Pages 451–462. https://doi.org/10.1016/j.ecolind.2017.08.015.

Grieken M, Dower B. (2017). Chapter 23 – Wind Turbines and Landscape. Wind Energy Engineering – A Handbook for Onshore and Offshore Wind Turbines. pp. 493–515. https://doi.org/10.1016/B978-0-12-809451-8.00023-0.

Hugh C. (1911). Socrates. Encyclopædia Britannica. Cambridge University Press.

Izveštaj o strateškoj proceni uticaja Plana detaljne regulacije za realizaciju agrosolarnog projekta „Agrosolar Kula" na životnu sredinu (2024). Investitor: Agrosolar d.o.o. Obrađivači: Projektura d.o.o, EKO-PLAN, RE-ECO, Beograd.

Izveštaj o strateškoj proceni uticaja Plana detaljne regulacije solarne elektrane Brebeks na životnu sredinu (2023). Ivestitor: Sage Solutions d.o.o. Obrađivači: Projektura d.o.o, EKO-PLAN, RE-ECO, Beograd.

Jay S, Jones C, Slinn P, Wood C. (2007). Environmental impact assessment: Retrospect and prospect. Environmental Impact Assessment Review, Volume 27, Issue 4. pp. 287–300. https://doi.org/10.1016/j.eiar.2006.12.001.

Jarčuška B, Gálffyová M, Schnürmacher R, Baláž M, Mišík M, Repel M, Fulín, Kerestúr D, Lackovičová Z, Mojžiš M, Zámečník M, Kaňuch P, Krištín A. (2024). Solar Parks Can Enhance Bird Diversity in Agricultural Landscape. Journal of Environmental Management, Vol 351. https://doi.org/10.1016/j.jenvman.2023.119902.

Josimović B. (2008). Implementation of Environmental Management System in Spatial Planning; University of Belgrade: Belgrade, Serbia, 2008. Available online: http://raumplan.iaus.ac.rs/handle/123456789/544

Josimović B. (2017). Prostorni aspekti uticaja vetroelektrana na životnu sredinu, IAUS, Beograd. https://raumplan.iaus.ac.rs/handle/123456789/542.

Josimović B, Bezbradica L, Manić B, Srnić D, Srebrić N. Cumulative Impact of Wind Farm Noise. Applied Sciences. 2023; 13(15):8792. https://doi.org/10.3390/app13158792.

Josimović B, Crnčević T. (2009). Impact Evaluation Within Strategic Environmental Assessment: The Case Study of the Waste Management Regional Plan for Kolubara region in Serbia. Environmental Engineering and Management Journal No. 3, Vol. 8, IASI, pp. 457–462. https://doi.org/10.30638/eemj.2009.062.

Josimović B, Crnčević T. (2010). Implementation of Strategic Environmental Assessment in Serbia with Special Reference to the Regional Plan of Waste Management. Environmental Management, edited by Santosh Kumar Sarkar, book published by SCIYO, pp. 95–113, ISBN 978-953-307-133-6. https://doi.org/10.5772/10101.

Josimović B, Crnčević T. (2012). The development of renewable energy capacities in Serbia: Case Study of three small hydropower plants in the Golija biosphere reserve with special reference to the landscape heritage. Renewable Energy Journal, Vol. 48, pp. 537–544. http://dx.doi.org/10.1016/j.renene.2012.06.015.

Josimović B, Cvjetić A, Furundžić D. Strategic Environmental Assessment and the precautionary principle in the spatial planning of wind farms – European experience in Serbia. Renewable and Sustainable Energy Reviews 2021, 136, 110459. https://doi.org/10.1016/j.rser.2020.110459.

Josimović B, Cvjetić A, Manić B. Strategic Environmental Assessment in the Application of Preventive Protection for Wind Farm Noise – Case Study: Maestrale Ring Wind Farm. Energies. 2021; 14(19):6174. https://doi.org/10.3390/en14196174.

Josimović B, Krunić N. (2008). Implementation of GIS in selection of locations for regional landfill in the Kolubara region. SPATIUM 17/18, IAUS, Belgrade. pp. 72–77. https://doi.org/10.2298/SPAT0818072J .

Josimović B, Krunić N, Gajić A. (2021)a. Multi-criteria Evaluation in Strategic Environmental Assessment in the Creation of a Sustainable Agricultural Waste Management Plan for Wineries: Case Study: Oplenac Vineyard. J Agric Environ Ethics 34, 4 (2021). https://doi.org/10.1007/s10806-021-09846-3.

Josimović B, Bezbradica Lj, Manić B, Srnić D, Srebrić N. (2023)b. Cumulative Impact of Wind Farm Noise. Applied Sciences 13, no. 15: 8792. https://doi.org/10.3390/app13158792.

Josimović B, Krunić N, Nenković-Riznić M. (2016)a. The impact of airport noise as part of a Strategic Environmental Assessment, Case Study: The Tivat (Montenegro) Airport expansion plan. Transportation Research Part D: Transport and Environment, Volume 49, pp. 271–279, https://doi.org/10.1016/j.trd.2016.10.005 .

Josimović B, Manić B, Krunić N. (2022). Strategic Environmental Assessment as a Support in a Sustainable National Waste Management Program – European Experience in

Serbia. Energies 2022, 15, 4568. https://doi.org/10.3390/en15134568.

Josimović B, Marić I, Manić B. (2011). Metodološki pristup u određivanju lokacije deponije komunalnog čvrstog otpada – studija slučaja: Regionalna deponija za Kolubarski region (Methodological approach to the determination of landfill location for municipal solid waste: Case study: Regional landfill in Kolubara region). Arhitektura i urbanizam, 55–64. https://doi.org/10.5937/arhurb1132055J.

Josimović B, Marić I, Milijić S. (2015). Multi-Criteria Evaluation in Strategic Environmental Assessment for Waste Management Plan, A Case Study: The City of Belgrade. Waste Management 36, pp. 331–342. https://doi.org/10.1016/j.wasman.2014.11.003.

Josimović B, Nenković-Riznić, Milijić S. (2016). Strategic Environmental Assessment as an Instrument for Sustainable Development of the Danube Corridor Through Serbia. Energy and Environment Research, Vol. 6, No. 1, ISSN 1927-0569, E-ISSN 1927-0577. https://doi.org/10.5539/eer.v6n1p1.

Josimović B, Petrić J. (2006). First regional landfill in Serbia – location choice. Environmental engineering and management, No. 3. pp. 391–399, ISSN 1582-9596. https://doi.org/10.30638/eemj.2006.029.

Josimović B, Petrić J, Milijić S. (2014). The Use of the Leopold Matrix in Carrying out the EIA for Wind Farms in Serbia. Energy and Environment Research, Vol. 4, No. 1. pp. 43–54. ISSN 1927-0569. doi: 10.5539/eer.v4n1p43.

Josimović B, Pucar M. (2010). The Strategic Environmental Impact Assessment of Electric Wind Energy Plants: Case Study Bavaniste (Serbia Renewable Energy Journal, Vol. 35, Issue 7, pp. 1509–1519, https://doi.org/10.1016/j.renene.2009.12.005.).

Josimović B, Srnić D, Manić B, Knežević I. Multi-Criteria Evaluation of Spatial Aspects in the Selection of Wind Farm Locations: Integrating the GIS and PROMETHEE Methods. Applied Sciences. 2023a; 13(9):5332. https://doi.org/10.3390/app13095332.

Josimović B, Todorović D, Jovović A, Manić B. Air pollution modeling to support strategic environmental assessment: case study – National Emission Reduction Plan for coal-fired thermal power plants in Serbia. Environment, Development and Sustainability 2023, https://doi.org/10.1007/s10668-023-03186-0.

Kalnins S.N, Gusca J, Pubule J, Borisov A, Blumberga D. (2016). Applicability of Combined Project Evaluation Methodology to EIA Projects. Energy Procedia, Volume 95, September 2016, pp. 424–428. https://doi.org/10.1016/j.egypro.2016.09.052.

Kangas J, Kanga, A. (2005). Multiple criteria decision support in forest management – approach, methods applied, and experiences gained. Forest Ecology and Management, Vol. 207, pp. 133–143. https://doi.org/10.1016/j.foreco.2004.10.023.

Ko I. (2023). Perspective Rural opposition to landscape change from solar energy: Explaining the diffusion of setback restrictions on solar farms across South Korean counties. Energy Research & Social Science 99(2023)103073. https://doi.org/10.1016/j.erss.2023.103073.

Konvencija o očuvanju evropske divlje flore i faune i prirodnih staništa („Službeni glasnik RS", br. 102/2007).

Krunić N, Josimović B, Gajić A, Nenković-Riznić M. (2019). Territorial analysis as support to the Strategic Environmental Assessment process for agro-waste management planning. Spatium, Vol. 2019, No 42. https://doi.org/10.2298/SPAT1942016K.

Krunić N, Josimović B, Milijić S, Ristić V (2017). Strategic Environmental Assessment as an instrument for sustainable spatial planning of water accumulation basins. Fresenius Environmental Bulletin (FEB), Vol. 26, No. 2, pp. 1281–1290, ISSN 1018-4619. https://doi.org/10.5539/eer.v6n1p1.

Latinopoulos D, Kechagia K. (2015). A GIS-based multi-criteria evaluation for wind farm site selection. A regional scale application in Greece. Renewable Energy, Volume 78. pp. 550–560. https://doi.org/10.1016/j.renene.2015.01.041.

Liou ML, Yeh SC, Yu YH. (2006). Reconstruction and systemization of the methodologies for strategic environmental assessment in Taiwan. Environmental Impact Assessment Review, Volume 26, Issue 2, pp. 170–184. https://doi.org/10.1016/j.eiar.2005.08.003.

Marsden S. (2002). Strategic environmental assessment: an international overview. In: Marsden S, Dovers S, editors. Strategic environmental assessment in Australasia. NSW7 The Federation Press. pp. 1–23.

Maričić T, Josimović B. (2005). Pregled sistema strateške procene uticaja (SPU) u zemljama Jugoistočne Evrope, Arhitektura i urbanizam 16–17, Institut za arhitekturu i urbanizam Srbije, Beograd, str. 66–71, ISSN 0354-6055.

Mercier J, Ahmed K. (2004). EIA and SEA at the World Bank. Paper presented to Proceedings of the 8th Intergovernmental Policy Forum on Environmental Assessment in association with the IAIA, Vancouver, Canada.

Mirasgedis S, Tourkolias C, Tzovla E, Diakoulaki D. (2014). Valuing the visual impact of wind farms: An application in South Evia, Greece. Renewable and Sustainable Energy Reviews, Volume 39. pp. 296–311. https://doi.org/10.1016/j.rser.2014.07.100.

Muhammad K. A, Muhammad M, Qaiser A, Imran S. (2020). Assessing the integration of solar power projects: SWOT-based AHP-F-TOPSIS case study of Turkey. Environmental Science and Pollution Research 27(34). https://doi.org/10.1007/s11356-020-10782-4

Muralikrishna I.V, Manickam V. (2017). Chapter Six – Environmental Impact Assessment and Audit. Environmental Management Science and Engineering for Industry. pp. 77–111. https://doi.org/10.1016/B978-0-12-811989-1.00006-3.

National Renewable Energy Laboratory-NREL (2015). https://www.nrel.gov.

Needham J. (1959). Science and Civilisation in China. Vol. 3. C.U.P. p. 302.

Nenković-Riznić M, Josimović B, Milijić, S. (2014). SEA as Instrument in Responsible Planning of Tourism Destinations – Case Study of National Park Đerdap, Serbia. Journal of Environmental and Tourism Analyses, Vol. 2. pp. 5–18. ISSN 2286-2838. https://doi.org/10.15244/pjoes/61851.

Nilsson M, Björklund A, Finnveden G, Johansson J. (2005). Testing a SEA methodology for the energy sector: a waste incineration tax proposal. Environmental Impact Assessment Review, Volume 25, Issue 1. Pages 1–32. https://doi.org/10.1016/j.eiar.2004.04.003.

Nilsson M, Dalkmann H. (2001). Decision Making and Strategic Environmental

Assessment. Journal of Environmental Assessment Policy and Management, Volume 03, Issue 03, pp. 305–327. https://doi.org/10.1142/S1464333201000728.

Noorollahi Y, Yousefi H, Mohammadi M. (2016). Multi-criteria decision support system for wind farm site selection using GIS. Sustainable Energy Technologies and Assessments, Volume 13, February 2016, pp. 38–50. https://doi.org/10.1016/j.seta.2015.11.007.

Oudesa D, Stremke S. (2021). Next generation solar power plants? A comparative analysis of frontrunner solar landscapes in Europe. Renewable and Sustainable Energy Reviews 145(2021)111101. https://doi.org/10.1016/j.rser.2021.111101.

Partidário M. R. (1996). Strategic environmental assessment: Key issues emerging from recent practice. Environmental Impact Assessment Review, Volume 16, Issue 1. pp. 31–55. https://doi.org/10.1016/0195-9255(95)00106-9.

Partidario MR. (2000). Elements of an SEA framework – improving the added-value of SEA. Environmental Impact Assessment Review, Volume 20, Issue 6. pp. 647–663. https://doi.org/10.1016/S0195-9255(00)00069-X.

Pedro J, Silva C, Pinheiro M.D. (2017). Scaling up LEED-ND sustainability assessment from the neighborhood towards the city scale with the support of GIS modeling: Lisbon case study. Sustainable Cities and Society. In Press. Available online 1 November 2017. https://doi.org/10.1016/j.scs.2017.09.015.

Perlin J. (2004). Solar Energy, History of. Encyclopedia of Energy. pp. 607–622. https://doi.org/10.1016/B0-12-176480-X/00035-8.

Podimata M. (2016). Methodological approach to EIA due to gas pipeline failure after an earthquake. The case study of the Trans Adriatic Pipeline. Journal of Natural Gas Science and Engineering, Volume 35, Part A, September 2016, pp. 1200–1206. https://doi.org/10.1016/j.jngse.2016.09.043.

Pravilnik o nacionalnoj listi indikatora zaštite životne sredine („Službeni glasnik RS", br. 37/2011).

Pravilnik o proglašenju i zaštiti strogo zaštićenih i zaštićenih divljih vrsta biljaka, životinja i gljiva („Službeni glasnik RS", br. 5/2010, 32/2016, 98/2016).

Pravilnik o kriterijumima za izdvajanje tipova staništa, o tipovima staništa, osetljivim, ugroženim, retkim i za zaštitu prioritetnim tipovima staništa i o merama zaštite za njihovo očuvanje („Službeni glasnik RS", br. 35/2010).

Protocol on Strategic Environmental Assessment, UNECE, 2003.

Renewables global status report, 2022. REN21 (http://www.ren21.net).

Salhofer S, Wassermann G, Binner E. (2007). Strategic environmental assessment as an approach to assess waste management systems. Experiances from an Austrian case study. Environmental Modelling & Sofware, Volume 22, Issue 5, pp. 610–618. https://doi.org/10.1016/j.envsoft.2005.12.031.

Saraji M. K, Streimikiene D, Suresh V. (2024). A novel two-stage multicriteria decision-making approach for selecting solar farm sites: A case study. Journal of Cleaner Production Volume 444. https://doi.org/10.1016/j.jclepro.2024.141198.

Sheate W, Richardson J, Aschemann R, Palerm J, Stehen U. (2001). SEA and integration of the environment into strategic decision-making, vol. 1. Main Report to the

European Commission, London.

Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine („Službeni glasnik RS", br. 101/15).

Studija energetskog potencijala Srbije za korišćenje sunčevog zračenja i energije vetra (NPEE, Evidencioni broj EE704-1052A). Univerzitet u Beogradu, Centar za multidisciplinarne studije, Beograd, novembar 2004.

SOlARGIS, 2021. https://solargis.com/

Therivel R, Partidario MR. (1996). SEA methodology in practice. The practice of strategic environmental assessment. London/Earthscan Publications. pp. 30– 44.

Tomić Z. (2016). Arhimedov blistavi um. www.svetnauke.org. Pristupljeno 25. jula 2023. godine.

Uredba o graničnim vrednostima zagađujućih materija u površinskim i podzemnim vodama i sedimentu i rokovima za njihovo dostizanje („Službeni glasnik RS", broj 50/2012).

Uredba o kategorizaciji državnih puteva („Službeni glasnik RS", broj 105/13, 119/13 i 93/15).

Uredba o načinu i postupku upravljanja otpadom od građenja i rušenja („Sl. glasnik RS", br. 93/2023 i 94/2023 – ispr.).

Uredba o Programu ostvarivanja Strategije razvoja energetike Republike Srbije do 2025. godine s projekcijama do 2030. godine („Službeni glasnik RS", br. 104/17).

Uredba o utvrđivanju Liste projekata za koje je obavezna procena uticaja i Liste projekata za koje se može zahtevati procena uticaja na životnu sredinu („Službeni glasnik RS", br. 114/08).

Vodolazhskaya L, Larenok P, Nevsky M. (2014). Ancient Astronomical Instrument from Srubna Burial of Kurgan Field Tavriya-1 (Northern Black Sea Coast). Archaeoastronomy and Ancient Technologies, 2(2), pp. 31–53.

White L, Noble B.F. (2013). Strategic environmental assessment for sustainability: A review of a decade of academic research. Environmental Impact Assessment Review, Volume 42. pp. 60–66. https://doi.org/10.1016/j.eiar.2012.10.003.

World Bank, 2020. http://www.worldbank.org/.

World Population Review, 2023. https://worldpopulationreview.com/

www.adtsolar.com/renewable-energy/history-of-solar-energy-part-5/, pristupljeno 25. jula 2023. godine.

www.sciencephoto.com/media/813943/view/archimedes-heat-ray-siege-of-syracuse-212-bc, pristupljeno 25. jula 2023. godine.

www.solartribune.com/the-history-of-solar-energy/, pristupljeno 27. jula 2023. godine.

Zakon o planiranju i izgradnji, „Službeni glasnik RS", br. 72/2009, 81/2009 – ispr., 64/2010 – odluka US, 24/2011, 121/2012, 42/2013 – odluka US, 50/2013 – odluka US, 98/2013 – odluka US, 132/2014, 145/2014 83/2018, 31/2019, 37/2019 – dr. zakon, 9/2020, 52/2021 i 62/2023).

Zakon o potvrđivanju Konvencije o biološkoj raznovrsnosti – Rio konvencija („Službeni list SRJ", broj 11/2001).

Zakon o potvrđivanju Konvencije o očuvanju evropske divlje flore i faune i prirodnih staništa – Bernska konvencija („Službeni glasnik RS", br. 102/2007).

Zakon o potvrđivanju Konvencije o očuvanju migratornih vrsta divljih životinja – Bonska konvencija („Službeni glasnik RS", br. 102/07).

Zakon o proceni uticaja na životnu sredinu („Službeni glasnik RS", br. 135/04 i 36/09).

Zakon o strateškoj proceni uticaja na životnu sredinu („Službeni glasnik RS", br. 135/2004 i 88/2010).

Zakon o zaštiti prirode RS („Službeni glasnik RS", br. 36/2009a, 88/2010, 91/2010 – ispravka, 14/2016, 95/2018 – drugi zakon, 71/2021).

Zakon o zaštiti životne sredine („Službeni glasnik RS", 135/04, 36/09 72/09, 43/11 –Ustavni sud, 14/2016, 76/2018, 95/2018 – dr. zakon i 95/2018 – dr. zakon).

Zionts S. (1979). MCDM – if not a Roman numeral, then what? Interfaces 9, pp. 94–101.

Zionts S, Wallenius J. (1976). An interactive programming method for solving the multiple criteria problem. Management Science 22, pp. 652–663.

Zárate-Toledo E, Paul Wood P, Patiño R. (2021). In search of wind farm sustainability on the Yucatan coast: Deficiencies and public perception of Environmental Impact Assessment in Mexico. Energy Policy, Volume 158. https://doi.org/10.1016/j.enpol.2021.112525.

https://nationalgeographic.rs/proizvedi-energiju/a27928/Koriscenje-energije-sunca-kroz-istoriju.html

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REZIME

Globalni trend smanjenja ugljeničnog otiska uticao je na dinamičan razvoj projekata koji koriste OIE, uključujući i razvoj solarne energetike u velikim solarnim elektranama, zbog čega se javila potreba za sagledavanjem uticaja koje ovi projekti imaju na prostor i životnu sredinu.

U knjizi je konstatovano da uticaji projekata koji koriste OIE, uključujući i solarne elektrane, mogu imati i pozitivne i negativne uticaje na prostor i životnu sredinu, a koje neizostavno treba utvrditi u cilju izbora optimalnih prostornih/teritorijalnih rešenja kojima se obezbeđuje preventivna planska i aktivna zaštita životne sredine. U tom procesu do izražaja dolazi primena strateške procene uticaja na životnu sredinu (SPU) u planiranju i prostornoj organizaciji solarnih elektrana.

SPU karakteriše holistički pristup, u kom je u najranijoj fazi razvoja projekta (u procesu planiranja) moguće sagledati kompleksne interakcije i korelacije u prostoru u kom se planira realizacija solarne elektrane, a zatim primeniti princip preventivne zaštite kako bi se negativni uticaji eliminisali ili umanjili, a pozitivni uticaji utvrdili. Na taj način moguće je predupprediti sve potencijalne rizike koji mogu nastati u kasnijim fazama realizacije projekta, što je povoljno i sa aspekta efikasne zaštite životne sredine i iz ugla investitora koji ulažu u projekte solarnih elektrana.

Optimalna rešenja kojim se ostvaruje osnovna uloga SPU traže se prvenstveno u analizi prostornih odnosa solarne elektrane prema zemljištu, biodiverzitetu, predelu i osnovnim činiocima životne sredine. Kako je u knjizi prikazano, ovaj proces se, u metodološkom smislu, ostvaruje kombinacijom različitih metodoloških pristupa i metoda za procenu uticaja, kao deo jedinstvenog semikvantitativnog metoda višekriterijumske evaluacije planskih rešenja.

Teorijska saznanja primenjena su u knjizi na studiji slučaja kompleksa solarne elektrane Brebeks, što je prikazano u drugom (aplikativnom) delu knjige, na osnovu čega je zaključeno da primenjeni pristup SPU predstavlja pogodnu podršku u proceni uticaja solarne elektrane na životnu sredinu, preventivnoj zaštiti životne sredine na području na kom se planira izgradnja solarne elektrane i procesu donošenja optimalnih odluka o prostornom razvoju na području planirane solarne elektrane.

SUMMARY

The global trend of reducing the "carbon footprint" has influenced the dynamic development of projects utilizing renewable energy sources (RES), including the expansion of solar energy in large-scale solar power plants. This has led to the need for assessing the impacts these projects have on the space and the environment.

The book notes that projects using RES, including solar power plants, can have both positive and negative impacts on the space and the environment, which must be determined to choose optimal spatial/territorial solutions ensuring preventive planning and active environmental protection. In this process, the application of Strategic Environmental Assessment (SEA) in the planning and spatial organization of solar power plants becomes significant.

SEA involves a holistic approach where complex interactions and correlations in the space where the solar power plant is planned for implementation can be considered in the earliest stages of project development (in the planning process). The principle of preventive protection can then be applied to eliminate or mitigate negative impacts and ascertain positive impacts. This approach enables the anticipation of all potential risks that may arise in later stages of project implementation, which is beneficial both in terms of efficient environmental protection and from the perspective of investors investing in solar power projects.

Optimal solutions to fulfill the primary role of SEA are primarily sought in the analysis of spatial relationships of the solar power plant with land, biodiversity, landscape, and basic environmental factors. As demonstrated in the book, this process, methodologically, is achieved through a combination of various methodological approaches and impact assessment methods, as part of a unified semi-quantitative method of multicriteria evaluation of planning solutions.

Theoretical knowledge applied in the book is exemplified in a case study of the "Brebex" solar power plant complex, as shown in the second (applicative) part of the book. It is concluded based on this case study that the applied SEA approach provides suitable support in: assessing the impact of the solar power plant on the environment; preventive environmental protection in the area where the construction of the solar power plant is planned; and the process of making optimal decisions on spatial development in the area of the planned solar power plant.

BIOGRAFIJA AUTORA

Boško Josimović rođen je 1974. godine u Zemunu gde je završio osnovnu i srednju školu. Diplomirao je 2000. godine na Geografskom fakultetu Univerziteta u Beogradu, na odseku za prostorno planiranje. Magistrirao je 2003. godine, a doktorirao 2008. godine takođe na Geografskom fakultetu Univerziteta u Beogradu, na smeru istraživanje i planiranje prostora.

U periodu 2002.-2003. godine bio je angažovan u Institutu za arhitekturu i urbanizam Srbije (IAUS) kao stipendista Ministarstva za nauku, tehnologije i razvoj Republike Srbije, a od septembra 2003. godine zaposlen je u IAUS-u gde i danas radi. U martu 2009. godine izabran je u zvanje naučni saradnik, 2013. godine u zvanje viši naučni saradnik, a 2018 godine u zvanje naučni savetnik. Od 2017. Godine je koordinator nacionalne i međunarodne naučne i stručne saradnje u oblasti životne sredine i prostornog razvoja u IAUS-u.

Uža naučnoistraživačka specijalnost usmerena je na razvoj metodološkog pristupa u proceni uticaja strateških razvojnih politika i projekata na životnu sredinu u oblastima: prostornog i urbanističkog planiranja, energetike (posebno vetroenergetike i solarne energetike), upravljanja vodama, itd. U okviru navedenih tema objavio je preko 100 naučnih radova od kojih značajan broj u vrhunskim međunarodnim časopisima. Autor je i prvi koautor u tri naučne monografije. Pored toga, bio je učesnik u realizaciji: 7 naučnoistraživačkih projekata koji su finansirani od strane resornog Ministarstva za oblast nauke; rukovodilac (ispred IAUS-a) jednog međunarodnog naučnog projekta (HORIZON 2020); autor preko 20 tehnoloških razvojnih rešenja koja su verifikovana od strane nadležnog Matičnog naučnog odbora Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije.

Profesionalna aktivnost Boška Josimovića usmerena je na rukovođenje u izradi: strateških procena uticaja razvojnih sektorskih politika na životnu sredinu; studija o proceni uticaja projekata na životnu sredinu; priloga o zaštiti životne sredine u prostornim planovima; itd. Značajno je i njegovo angažovanje kao konsultanta na projektima u oblasti infrastrukture koji se realizuju u Republici Srbiji, a finansiraju se iz sredstava Evropske unije.

Član je: Skupštine Alumnija Univerziteta u Beogradu, međunarodne naučne asocijacije SCIYO-a, organizacije SEEFED; nekoliko strukovnih udruženja; republičke Tehničke komisije za ocenu studija o proceni uticaja na životnu sredinu pri Ministarstvu za zaštitu životne sredine Republike Srbije; Naučnog veća i Izdavačkog saveta IAUS-a; Uredništva časopisa Arhitektura i urbanizam.

Oženjen je i ima dvoje dece.

ABOUT THE AUTHOR

Boško Josimović was born in 1974 in Zemun, where he completed his elementary and high school education. He graduated in 2000 from the Faculty of Geography, University of Belgrade, Department of Spatial Planning. He obtained his master's degree in 2003 and his Ph.D. in 2008, also at the Faculty of Geography, University of Belgrade, specializing in spatial research and planning.

From 2002 to 2003, he was engaged at The Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS) as a scholarship holder of the Ministry of Science, Technology, and Development of the Republic of Serbia. Since September 2003, he has been employed at IAUS, where he still works today. In March 2009, he was appointed as a Scientific Associate, in 2013 as a Senior Scientific Associate, and in 2018 as a Scientific Advisor. Since 2017, he has been the coordinator of national and international scientific and professional cooperation in the field of environmental and spatial development at IAUS.

In terms of scientific research, he specializes in developing a methodological approach to assessing the impacts of strategic development policies and projects on the environment in the fields of spatial and urban planning, energy (particularly wind and solar energy), water management, etc. He has published over 100 scientific papers about these topics, many of which in top-tier international journals. He is the author and co-author of three scientific monographs. Additionally, he participated in the implementation of seven research projects funded by the Ministry of Science; he led (on behalf of IAUS) an international scientific project (HORIZON 2020); he authored over 20 technological development solutions verified by the relevant Principal Scientific Committee of the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia.

Boško Josimović's professional activities focus on leading the development of strategic environmental impact assessments of sectoral development policies, project environmental impact assessment studies, contributions to environmental protection in spatial plans, etc. His involvement as a consultant on infrastructure projects implemented in the Republic of Serbia and funded by the European Union is also significant.

He is a member of the Alumni Assembly of the University of Belgrade, the international scientific association SCIYO, the SEEFED organization, several professional associations, the State Technical Commission for Environmental Impact Assessment Studies at the Ministry of Environmental Protection of the Republic of Serbia, the Scientific Council and the Editorial Board of IAUS, and the Editorial Board of the journal Architecture and Urbanism.

He is married and has two children.

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