USING MINE LANDS AND OTHER BROWNFIELDS FOR SOLAR AND WIND POWER DEPLOYMENT IN NORTH MACEDONIA: STUDY AND METHODOLOGY

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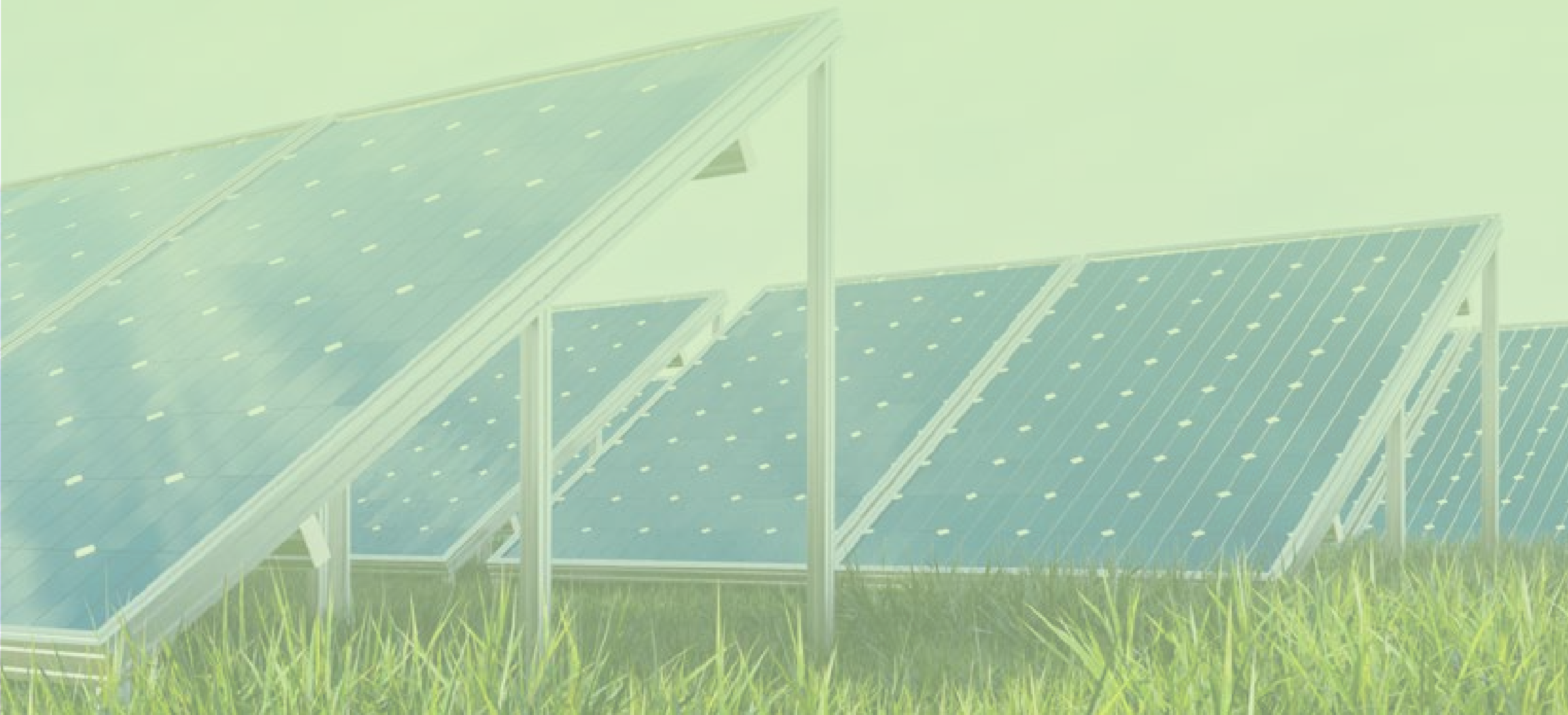

EXTENDED EXECUTIVE SUMMARY

Driven by Paris Agreement goals, the transition to clean energy will require a significant global buildout of renewable energy generation. Most of these projects will necessitate large areas for development. Therefore, brownfields, including locations such as abandoned mines, are becoming more attractive, as they already have some infrastructure that could be utilised for renewable energy source (RES) installations.

Over the past few decades, many studies and papers have researched the possibilities for redevelopment or reuse of brownfields.

The Nature Conservancy's recent Study on Clean and Green Pathways for the Global Renewable Energy Buildout[1] identifies six pathways for promoting utility-scale solar and wind energy in places with low-impact on nature and supported by local communities. The study includes several examples from the USA, among which is the Restoration Design Energy Project (RDEP) launched by the Bureau of Land Management (BLM) in 2009 to identify disturbed or previously developed sites within its portfolio of lands, such as brownfields, that could be made available for renewable energy development. Based on an extensive public outreach process, the BLM and other public entities identified 64 previously disturbed sites on federal, state, municipal, and private lands that may potentially be suitable for renewable energy development. Site types include gravel pits, mine sites, landfills, isolated parcels that have been disturbed, marginal or impaired agricultural lands, abandoned unauthorised airstrips, and Central Arizona Project (CAP) land.[2] The sites assessments were performed by giving a weighted score for each of the sites on a scale of 0 (least development potential) to 100 (best development potential), based on general topographic and property size suitability (e.g., the slope of the terrain for solar projects); solar resource availability; wind potential rating; distance to existing transmission and distribution lines, interconnections, and roads; distance to different types of load centres; and the presence of sensitive resources and potentially incompatible land use designations.

A similar assessment of the potential for renewable energy development on brownfields in North Macedonia has not been completed. However, there is likely a high potential given the expected demand for renewable energy systems and the quantity of potentially suitable brownfields.

By 2040, about 1400 MW solar power plants and 750 MW wind power plants should be built in North Macedonia, as defined in the Strategy for Energy Development until 2040. With these installed RES

1 McKenney, Bruce and Jessica Wilkinson, "*Clean and Green Pathways for the Global Renewable Energy Buildout*", The Nature Conservancy, Arlington, VA, 2020.
2 Arizona Restoration Design Energy Project, "*Solar and Wind Energy Assessment of Nominated Sites*", 2012.

capacities and also investment in hydropower plants, it is expected that the current mix of electricity generation will be modified so that, by 2040, over 80% of electricity will be produced from RES, opposite to the current situation where lignite-fired power plants contribute 80% of domestic production.

To accomplish the 2040 vision, there is an urgency for RES development which is in close proximity to the transmission and distribution network's capacity and the locations where they will be built. In addition, numerous limitations need to be taken into consideration, and various stakeholders should take part in planning the future energy system development. In this study, special attention is given to brownfields and mines in particular, as potential locations that can be redeveloped, and can now be used as sites for renewable energy sources. Therefore, this study first gives an analysis of the legal aspect of brownfield investments in renewable energy sources, giving an overview of all the relevant laws and rulebooks that should be considered in this type of investment. Additionally, a financial analysis of the investments in renewable energy on brownfields is also presented, outlining the different types of costs and parameters for assessing the economic efficiency and profitability of the investments, as well as potential parameters and factors that determine the location of photovoltaic (PV) and wind power plants (WPPs).

LEGAL ASPECT OF BROWNFIELD INVESTMENTS

As the main potential for brownfield investments is expected to be located in mining areas – abandoned mines or mines expected to be abandoned, as well as mining sites that allow for additional production facilities to be built therein - the legal analysis primarily focuses on the national legislation related to mineral resources. In that respect, the key laws are:

- **Law on Mineral Resources** that determines that mineral resources are considered as a property of the Republic of North Macedonia, therefore, the only way they can be exploited is by obtaining a concession from the competent state body, and
- **Law on Concessions and Public Private Partnerships** that has to be observed in the procedure for awarding concession for exploiting mineral resources, making the provisions of this law related to contract duration, ownership rights and transfer, of relevance for the brownfield investments.

In addition, the following pieces of legislation have been also analysed due to their relevance in the identification and use of sites for the construction of RE generating facilities:

- **Law on Environment** as an umbrella law that entails certain types of environmental impact assessments to be conducted, even for RES generating facilities,
- **Law on Urban Planning** that elaborates the procedures for urbanising certain pieces of land, thus making the construction of generation facilities on them possible, and
- **Rulebook on Urban Planning** that defines the type of class purpose of each piece of urbanised land, where the mining and energy facilities belong, as well as the flexibility for changing the initially defined purpose class.

For each relevant piece of legislation, its subject matter and a review of the most important provisions are provided, ending with a brief conclusion on their applicability for brownfield investments in RES or if changes might be necessary. In general, the present legal framework is favourable for brownfield investments in RES, while certain modifications may contribute to further improvement and legal certainty.

There seems to be quite a discrepancy between what is written in the **Law on Mineral Resources** and what is happening in practice. First, the Government has not yet adopted its Strategy for Geological Surveys, Sustainable Use and Exploitation of Mineral Resources for a period of 20 years, which, as with any strategic document, should set the guidelines in terms of the type and quantity of land that could and should be used for geological surveys and exploitation, specific activities that would be taken to make the land and exploitation field sustainable, etc. Second, the Government has not adopted an annual programme for rehabilitation and recultivation that will define more precisely the land/area that will be subject to rehabilitation (*cleaning the land that had been affected by tailings* *installation, in a way that the land returns to a satisfactory condition, especially in terms of soil quality, wildlife, natural habitats, freshwater systems, landscape and the appropriate usefulness of it*) and recultivation (*returning to a useful condition, the land which was degraded by geological survey or by the exploitation and processing of mineral resources*) as mandatory activities in each concession awarded.

The Law on Mineral Resources allows infrastructure facilities to be built in the concession area and exploitation field if they are of public interest and do not disrupt the exploitation of mineral resources. According to the Energy Law, the construction and operation of an RE generation facility is an activity of public interest, therefore, they can be constructed within a mine site that is still operational. These provisions provide additional possibilities for brownfield investments.

The **Law on Concessions and Public-Private Partnerships** (PPP) regulates the procedural aspects of awarding concessions and PPP. However, the provisions related to contract duration, its transferability and ownership rights on the concession subject are important for brownfield investments. Contracts' duration can be shorter than 35 years, meaning that many actual concessions for exploitation of mineral resources may expire in the near future and be used for other purposes if the exploitation of the site is exhausted. The Public Partner remains the owner or obtains the ownership after the expiration of the concession period and can decide upon the future of that land and facilities built on it. This means that the state as Public Partner can, without any modifications in the law, decide on the land use purpose, whether further concession for exploitation of mineral resources will be awarded or PPP for construction and operation of RES generation facility will be established.
The **Law on Environment** and bylaws deriving from it, provide for different treatment (necessary environmental documents) for different types of RE technologies. Investors in hydropower and wind power plants with an installed capacity of up to 10 MW and other RES power plants with an installed capacity of up to 200 MW must develop environmental 'elaborat'[3] which should be submitted for approval to the Ministry of Environment and Physical Planning. Projects for which an environmental impact assessment procedure must be conducted, which is more complex and time-consuming than the procedure for approval of environmental elaborat' include large hydro power plants with an installed capacity of over 10 MW and installations for use of wind power for electricity generation (so called wind farms).

3 According to Macedonian Law on Environment, Legal entities or natural persons whose activities or works do not comprise projects that are subject to an environmental impact assessment procedure, must develop environmental impact assessment 'elaborat' and submit it to the body of the state administration responsible for the project approval and implementation. 'Elaborat' represents rapid and less detailed environmental impact assessment.

Strategic assessment is carried out on planning documents if they envisage the implementation of projects for which an environmental impact assessment procedure is implemented or which affect the protected areas. This includes, among other things, all short-term, medium-term and long-term mining and energy planning documents, as well as individual energy activities to ensure the security of supply of various types of energy.

The **Law on Urban Planning** fails to regulate important issues such as the period for which the national Spatial Plan will be adopted, the procedure for its adoption and modification, as well as its basic content. The present national Spatial Plan was adopted in 2004 for the period up to 2020; there is an obvious need for a new one to be adopted, thus providing legal certainty in the procedure for adopting spatial and urban plans at the hierarchical lower level.

The following types of plans are adequate for the planning of RES generation facilities:

- **Urban plan for outside settlement boundaries** adopted for, among other things, larger constructions or infrastructure construction of local importance, located outside a settlement, and
- **Urban plan for areas and buildings of state importance** adopted for areas with superstructural and infrastructural complexes, systems, buildings and accompanying buildings of state importance.

Procedures for adoption of an urban plan for outside settlement boundaries can run up to 18 months, while urban plans for areas and buildings of state importance may take up to 36 months. The Law provides a possibility for the land covered by the adopted urban plan to remain agricultural land, which seems quite convenient for those urban plans that envisage construction of an infrastructure line (e.g. connection to the grid) or even PV power plant, where the technology is the least degradable for the land, if it would be degraded at all. In case the RES power plant is to be built on a single cadastral parcel, the procedure for adoption of the urban project can be directly initiated, without prior existence of an urban plan, thus shortening the investment period. In the case of brownfield investments, urban plans already exist, but they will most likely need to be modified to foresee another class purpose (the type of facility to be built), but the procedure for such modification is shorter than the procedure for adoption of a completely new urban plan.

Of particular relevance for brownfield investments is the section system of classes of purposes defined in the **Rulebook on Urban Planning**. Classes of purpose are an instrument used to define the land purpose in urban plans and urban projects. Even if an existing urban plan specifies the purpose class on the level of sub-class, that does not mean that changes are not possible, especially if the change is from a more rigid to a more flexible sub-class (e.g. change from sub-class D1 - Mining that is considered as a heavy and polluting industry into sub-class D3 - energy from renewable sources

where non-polluting technologies are applied).

To summarise, though in general, the present legal framework related to brownfield investments in RES generation capacities is favourable, further improvements are necessary:

- To expand the content of the Registry of Awarded Concessions by including data on the number of cadastre parcel and the type of land for which the concession is awarded, and provide these data to the developers of the annual indicative plan for construction of RES generation capacities, which is to be introduced with the amendments to the Energy Law.
- If need be, further to be clarified in the Law on Mineral Resources or with the responsible institution for monitoring the implementation of this Law that:
    - constructing RES power plants on the active exploitation field for which concession was awarded is possible on the grounds that construction and operation of RES power plants is an activity of public interest, and
    - rehabilitation and recultivation activities on the exploited mine site are not mandatory in the case of a facility of public interest to be constructed on it that does not entail rehabilitation and recultivation of that particular piece of land.

  If need be, further to be clarified in the Law on Urban Planning or with the responsible institution for monitoring the implementation of this Law that for construction of certain types of RES power plants (PV technology) that do not degrade the agricultural land, the adoption of an urban plan and above all conversion of agricultural into construction land is not necessary, thus shortening the investment procedures and creating legal certainty.

From a legal point of view, the easiest and fastest way to realise a brownfield investment in a RES power plant, which is to be built on an active or abandoned mine (exploitation) site, would be to change the class purpose from mining to production of energy from renewable sources in the existing urban plan and then, with the project design and other documents, obtain a construction permit. Going beyond brownfield investments would be the building of an RES power plant (PV technology) on agricultural land of lower category that can be barely used for agriculture purposes, and in the procedure, for the adoption of the appropriate urban plan for that construction there will be no need for conversion of the agriculture into construction land.

FINANCIAL ASPECT OF BROWNFIELD INVESTMENTS

As part of the project, the following financial aspects were elaborated on: the general financial situation in the Republic of North Macedonia; the energy sector in the Republic of North Macedonia; FDI (greenfield and brownfield investments) in North Macedonia and the main economic parameters which determine the location of WPPs and PVPPs.

GENERAL FINANCIAL SITUATION OF THE REPUBLIC OF NORTH MACEDONIA

For an overview of the general financial situation in the country, this report presents the basic characteristics of the public finance system and the banking system of the Republic of North Macedonia.

Public finance system – Prior to 2008, North Macedonia maintained low budget deficits for a relatively long time period (1994 to 2008). In the period 2008-2014, the country doubled its public debt and lost its fiscal space. The situation with the public debt has become more complicated during the crisis caused by the COVID-19 pandemic. The budget deficit in 2020 exceeded 8%. By the end of 2020, the public debt as a share of GDP exceeded 60%. According to this indicator the country is classified in the group of moderately indebted countries – in fact, during the health crisis North Macedonia achieved the 11th lowest increase in the public debt among 32 European countries (European Commission: European Forecast, Institutional Paper No 136/2020).

Compared with the other countries in the region, North Macedonia has a relatively low share of public investments in its total public expenditure. However, North Macedonia has the potential for creating a wider fiscal space to increase public investments, mainly capital infrastructure investments, mostly in the field of energy transformation.

Banking sector – today the banking sector of North Macedonia consists of 14 banks, of which 5 are large, 6 medium and 3 small (classified by the size of assets). The banking system of the Republic of North Macedonia is the dominant segment of the financial system – it accounts for about 90% of the financial potential of the country's total financial system. The general assessment is that the banking system is stable, with a predominant share of foreign capital in the total capital of the banks (almost 70%), with solid capitalisation (the capital adequacy is 18% and is more than twice the legal minimum) and with significant progress in corporate governance. The Macedonian banking system was not hard hit by the current crisis. The credit potential of the banks remains solid – they are able to finance profitable projects from the Macedonian business sector without problem, further, they are increasingly granting eco-loans (to companies and households), including loans for renewable energy sources and the improvement of energy efficiency and are actively participating in the operationalisation of foreign credit lines which are mobilised through the only state bank in the country – Development Bank of North Macedonia.

Regarding the situation in the **balance of payments,** it should be stressed that North Macedonia has a chronic trade deficit, which predominantly results in a deficit in its current account balance (% of GDP), which in the years before the crisis (2010 – 2018) was maintained at an average annual level of -3% (our calculations based on data from the National Bank of the Republic of North Macedonia – www.nbrm.mk) but which is successfully covered by private transfer inflows (transfers – remittances of the Macedonian citizens working abroad), by borrowing at the international financial markets, and with FDI inflows. According to Standard & Poor's, **the credit rating** of North Macedonia remains stable during the crisis, i.e., **BB-/Stable/B**.

Recently, for financing of the green transition, North Macedonia has provided significant funds from foreign sources, under favourable conditions. At the same time the procedure for construction of the Cebren power plant has been accelerated (the largest investment in the energy sector in North Macedonia) and photovoltaic power plants are under construction by TPP Bitola. The Government of the Republic of North Macedonia is participating in the construction of the Alexandropoulos pipeline, with 10% of the total investment.

THE ROLE OF THE ENERGY SECTOR IN THE NATIONAL ECONOMY

Energy is the bloodstream of the economy because energy is a vital input in economic processes, and thus a constituent element of production costs and the prices of goods and services. Due to the pronounced energy deficit, North Macedonia is implementing an ambitious National Strategy for Energy Development until 2040. The energy transformation is based on several pillars: *firstly*, a significant increase in the share of renewable energy sources in total energy production (from 18% in 2019 to 50% in 2040); *second*, an increase in energy efficiency (reduction of energy consumption by 27% in the period from 2019 to 2040, with simultaneous GDP growth); *third*, reduction of greenhouse gas emission by 55% by 2040, compared with 1990; *fourth*, a change in the government regulation in the field of energy and energy policies and their compliance with EU standards and European Energy Community. Achieving the above-mentioned goals implies the beginning of a strong investment cycle in the energy sector, based on the implementation of innovative energy technologies – green investments. In the Strategy, the plan is to invest EUR 4.7 billion in energy, by 2025. The green investments in energy will have numerous effects: an increase in energy efficiency; preservation of jobs and creation of new jobs in the energy sector, and, through the employment multiplier, new jobs will be created in other sectors; the decarbonisation process, an increase of the share of renewable energy sources, and moving to the circular economy will contribute to the protection of the environment as one of the sustainable development components. As a result of the largest energy price shock at the global level, caused by the war in Ukraine, the country has started a process of intensified investment in renewable energy sources and energy efficiency. In the meantime, a change has been made in the legislation on renewable energy sources (Official Gazette No. 112.19): households and individuals now receive the status of prosumers and have the opportunity to install renewable energy power sources. The interest in this type of investment in the country is high, much more than expected, and the number of companies and households investing in renewable energy sources is constantly growing.

FOREIGN DIRECT INVESTMENTS – OVERVIEW OF GREENFIELD AND BROWNFIELD INVESTMENTS

There are two major types of international capital flows: **foreign direct investments (FDI) and portfolio investments (PI).**

Depending on the type of investment, foreign direct investment can be divided into two segments: *greenfield investments* and *brownfield investments.*

The Republic of North Macedonia is in the group of countries in transition and developing countries with a relatively weak performance in the area of attracting FDI. A decade after independence, FDI in the country, de facto, were absent or marginal. After 2006, the Government of the Republic of Macedonia promoted a strong stimulating policy for attracting FDI, especially in Technological Industrial Development Zones (TIDZ) and industrial zones. During the period (2006-2020), in North Macedonia, the average annual net FDI inflows amounted to USD 363.4 million, while the average annual net inflows as a share of GDP amounted to 3.6%. (UNCTAD: World Investment Report, 2019 p. 2016; p. 219).

Depending on the direction of the investment, the NBRNM's Statistical Survey on direct investments covers data for stocks and flows of Direct Investments abroad (Outward Direct Investments) and Direct Investments in the country (Inward Direct Investments). In addition, the direct investment statistics of NBRNM covers the annual FDI inflows and what is known as the stocks balance, (i.e. accumulated inflows for a certain period of time). Depending on the direct investments' structure, the Statistical Survey of the NBRNM for direct investments in the country covers stock data of new, existing, and other investments. Direct investments stocks data are valued at book value. Changes in stocks between two reporting periods may arise from transactions, price changes and/or exchange rate changes and other changes in volume https://www.nbrm.mk/direktni_investicii_sostojbi-en.nspx.

However, the NBRNM's statistics **do not monitor greenfield and brownfield investments separately, but provide converged data in the category of foreign direct investment**. For the needs of this project, the distinction between the two types of FDI is important, because the economic costs that determine the location of green investments in energy are usually lower in the case of brownfield investments, primarily due to the lower costs related to the necessary infrastructure and especially the electricity distribution network, further due to the fact that in a case where the location of the power plant is in an existing company (brownfield investments) there are savings in costs for education and training of employees, etc. But this aspect of the problem will be elaborated upon more widely in the next part on economic factors and parameters that determine the location of energy facilities.

ECONOMIC FACTORS AND PARAMETERS THAT DETERMINE THE LOCATION OF WIND AND SOLAR POWER PLANTS

DIFFERENT TYPES OF COSTS AND PARAMETERS FOR ASSESSING THE ECONOMIC EFFICIENCY AND PROFITABILITY OF THE INVESTMENTS

One of the most widely used methods for determining the efficiency and justification of the investments is the **cost-benefit analysis.** On the cost side, the average energy production costs are important, while on the benefit side of primary importance is the quantity of the energy produced. For this particular **cost-benefit analysis** on the cost side, the division of **investment** and **operation and maintenance (O&M) costs** are relevant.

The O&M costs of investments in renewable energy power plants are significantly lower and experience has shown that they represent around ¼ in the total costs, while the O&M of investments in conventional power plants are much higher and represent almost 80% in the total costs. In the later phases of the exploitation of power plants (wind power plants - WPPs and solar power plants - PVPs), of particular importance are the costs related to the **decommissioning of the power plant or its re-powering**. It should be considered that different components of the fixed costs have different useful life and depreciation periods. This has an impact on the costs of replacing the old equipment with new equipment. After the depreciation period, when the old equipment is replaced with new, these types of costs are significantly lower compared with the decommissioning, because some of the already made investments (for example – the road access infrastructure, and energy infrastructure) could be further used for the new investment. In this way, the fixed costs are reduced and thus the total average costs are lower.

On the **benefit side,** the most important indicator is energy production. Besides the energy production, other benefits classified as positive socio-economic benefits are evident: generating new jobs at the local level; being a source of revenues for local companies involved as subcontractors; the construction or improvement of road access infrastructure at the location of the investment.

IMPORTANT CONDITIONS FOR WIND AND PHOTOVOLTAIC POWER PLANT INVESTMENTS

PARAMETERS AND FACTORS THAT DETERMINE THE LOCATION OF WIND POWER PLANTS

The construction of wind power plants is determined by the wind speed and wind turbulence at the location (these are technical parameters, which, however, have a strong impact on the economic costs), along with factors such as the already existing energy infrastructure and access road infrastructure. To the extent that the location has a microclimate (a natural factor that also has an impact on the economic costs), and the climate is harsh (cold winters and hot summers) then the maintenance costs increase. To a lesser extent, the costs may be increased due to the preparation of studies for environmental protection generally, and separately for studies for protected areas or studies for the protection of archeological sites. The proximity of the planned location for investment to settlements (<500), may decrease the energy production due to the need to turn off the turbines because of excessive noise and shadow flicker.

The future electricity production, the profitability of the project and the period of return of the investment depend on the measured wind speed at the location. Locations with higher average wind speeds are more favourable for the construction of wind plants. The degree of turbulence of the wind can increase the investment costs due to the need for the installation of resilient types of wind turbines. At the same time, more frequent high turbulence can also increase the maintenance costs for the turbines.

The existing energy infrastructure can increase the construction costs in cases where the power grid is far away from the location for construction, and longer interconnection transmission lines and distribution lines should be constructed for a smaller wind power plant. The construction of a new substation for connection to the electricity network also has a significant impact on the investment and construction costs. The road access infrastructure can increase the investment costs in a case where the location is at a greater distance from the existing infrastructure and construction of longer access roads for the transport of the turbines is needed.

In sum, when building a wind plant at any location, first the essential condition should be met – the measured average wind speed of the micro-location, which directly influences the cost-effectiveness of the project as well as the period of return of the investment. If this essential condition is met, then the crucial economic factors should be considered.

When building wind plants on brownfields the following economic parameters as inputs in the cost-benefit analysis are of crucial importance:

Cost side: energy infrastructure; access to road infrastructure; costs for land acquisition and of the existing facilities; utility costs for construction; building permits; electricity generation licenses; costs for wildlife protection (birds, bats, etc.); cooperation with local subcontractors; an available qualified workforce that can be hired for the new investment; costs related to the proximity to settlements, protected areas, national parks and archaeological locations.

Benefit side: annual electricity production.

PARAMETERS AND FACTORS THAT DETERMINE THE LOCATION OF PHOTOVOLTAIC POWER PLANTS

In the case of photovoltaic power plants, the choice of the location is determined by the larger number of sunny days in the year, as well as the orientation of the location with regard to the Sun. As in the case of wind power plants, the existing energy infrastructure has an impact on the investment costs. The impact of the access road infrastructure is not as significant as in the case of the wind power plants. When building a photovoltaic power plant at some location, first the essential condition should be met, which are the average annual sunny days at the micro-location, which directly impacts the cost-effectiveness of the project as well as the period of return of the investment. If the essential condition is met, then the crucial economic factors should be considered.

When building photovoltaic power plants on brownfields, the following economic parameters as inputs in the cost-benefit analysis are of crucial importance:

Cost side: energy infrastructure; access road infrastructure; costs for land acquisition and of the existing facilities; utility costs for construction; building permits; electricity generation licenses; costs for wildlife protection (birds, bats, etc.); cooperation with local subcontractors; available qualified workforce that can be hired for the new investment; costs related with the proximity to settlements, protected areas, national parks and archeological locations.

Benefit side: annual electricity production.

The above-presented analysis confirms that building wind and photovoltaic power plants on brownfields is determined by numerous economic parameters and factors, but also by other factors, including technical, natural, environmental, etc. The technical, natural and environmental factors have a strong impact on the total investment costs and the average energy production costs, including the price of energy. Hence the choice of the most appropriate location for those types of power plants requires a complex analysis of all relevant factors because they are interdependent and together determine the final result – the optimal location for construction of the power plants.

To summarise:

- The Great Recession 2007-2009 and the COVID-19 recession has led to the significant limitation of the fiscal space in North Macedonia – in 2008, the debt to GDP ratio accounted for 24% and today more than 63%. Adequate fiscal space should be built in order to increase public investment and in particular to increase public investment in the energy sector. The increase in the share of public revenues can be predominantly based on the decrease of the grey economy (which is estimated at a level of 30% - 35% of GDP), through the prevention of tax evasion (this means an increase in the efficiency of tax administration) and through tax increase (progression in personal income tax). On the expenditure side of the budget, there is considerable space for cutting off the typically unproductive government public spending. These measures, together with improvement in the medium-term and long-term budget planning, can contribute to the expansion of the space for capital investments, including investment in energy. Due to the energy crisis, the implementation of the Government's strategy for fiscal consolidation is likely to slow down in the coming period, but it should not be abandoned.
- To improve the general financial situation, increase public and private investment and accelerate the economic growth in the country, the Government of the Republic of North Macedonia and the private sector should maximally use the funds for green investments from EBRD, EIB, KFW, UNDP, USAID, etc., as well as the innovative instruments for financing green growth, part of the Green Agenda for the Western Balkans.
- With the changes in the legislation in North Macedonia, households and individuals receive the status of prosumers and have the opportunity to install power sources for electricity production from renewable sources and to distribute the excess energy to the electricity distribution network.

The interest in investing in photovoltaics has increased (in households, individuals and businesses) but the procedures for obtaining permits are still complex. The Government should accelerate the simplification process and harmonise its regulation with EU standards. Although individually they present relatively small funds, in total, they are a large amount, which can contribute to the increase of the solar energy production in North Macedonia (280 sunny days a year and the highest quality peak of solar energy) and for the energy transformation of the country.

- To encourage and support investment in renewable energy on brownfields, to utilise the advantages they offer (existing electricity and road infrastructure; work force etc.)
- In the cost-benefit analysis for energy investments, on the cost side the investment and operation & maintenance costs are relevant, on the benefit side, the most important is the energy production, but also other socio-economic benefits are evident. Generally, it could be concluded that building wind plants and photovoltaic plants on depleted mines could be cost-beneficial but the following conditions should be fulfilled: relevant energy infrastructure; road infrastructure; available workforce etc.
- The technical, natural and environmental factors have a strong impact on the total investment costs and the average energy production costs. Hence, the choice of the most appropriate location requires a complex analysis of all relevant economic, social, environmental, technical and natural factors because they are interdependent and together determine the final result – the optimal brownfield location for construction of the power plants

CANDIDATE SITES AND SELECTION CRITERIA

PARAMETERS AND FACTORS THAT DETERMINE THE LOCATION OF WIND POWER PLANTS

This study focuses on potential brownfield sites, especially mines - existing, closed, and potential mines. For that purpose, a detailed map of their locations has been developed (Table 1, Figure 1). There are many potential locations of active or non-operational mines, and brownfields that in the future should be successfully transformed into locations for PV or wind plants. Besides the large coal mines “Oslomej” near Kichevo, “Suvodol”, “Brod Gneotino” and the potential coal mine “Zivojno” near Bitola, another coal mine in southwest North Macedonia is “Piskupshtina” near Struga with a capacity of 80-100 t annually. The same applies to the coal mine “Berovo”. Additionally, there is a coal mine in the vicinity of Skopje, “Katlanovo”, with total geological reserves of coal, calculated for the upper productive horizon at the site about 18.5 x 106 tons. Furthermore, in the eastern part of the country, there are several mines mostly for lead zinc ore, namely “Dobrevo (Zletovo)” near Probishtip, “Toranica” near Kriva Palanka, “Sasa” near Makedonska Kamenica. In the vicinity of Radovish, there are two mines, “Buchim” – the only copper mine in North Macedonia – and “Damjan” for iron ore. Close to Strumica, there is the feldspar mine “Hamzali – Drvosh”. In the southern part of the country, near Zovich, there are two mines, “Ruzhanovo” for ferronickel and “Alshar” known for the thallium mineral Lorandite. Going towards the centre of the country, in the vicinity of Prilep, the marble ore mine named “Sivec” can be found. Another iron ore mine, “Zhvan”, is located in the southwestern part of North Macedonia. Although the majority of the mines are not coal-based, they represent a development area by utilising the equipment, facilities, road and electricity connection that are already in place.

TABLE 1. AN INITIAL LIST OF MINES IN NORTH MACEDONIA

NAME OF MINE	TYPE OF MINE	NEAREST CITY	OPERATIONAL
Oslomej	Lignite	Kicevo	closed
Suvodol	Lignite	Bitola	partially under exploitation
Brod Gneotino	Lignite	Bitola	under exploitation
Zivojno	Lignite	Bitola	potential
Piskupstina	Lignite	Struga	under exploitation
Brik Berovo	Lignite	Berovo	under exploitation
Katlanovo	Lignite	Skopje	under exploitation
Dobrevo	lead zinc	Probistip (Zletovo)	partially under exploitation
Toranica	lead zinc	Kriva Palanka	partially under exploitation
Sasa	lead zinc	Mekedonska Kamenica	partially under exploitation
Buchim	Copper	Radovish	closed
Damjan	Iron ore	Radovish	closed
Borov Dol	Copper	Radovish/Stip	under exploitation
Hamzali - Drvosh	feldspar	Strumica	under exploitation
Ruzhanovo	Ferronickel	Kavadarci	closed
Alshar	Thallium mineral lorandite	Valandovo/Gevgelija	potential
Sivec	Marble ore	Prilep	under exploitation
Zhvan	Iron ore	Demir Hisar	closed
Izvor	Talc	Veles	
Knauf	Gypsum	Debar	under exploitation
Tajmiste	Iron ore	Kicevo	under exploitation

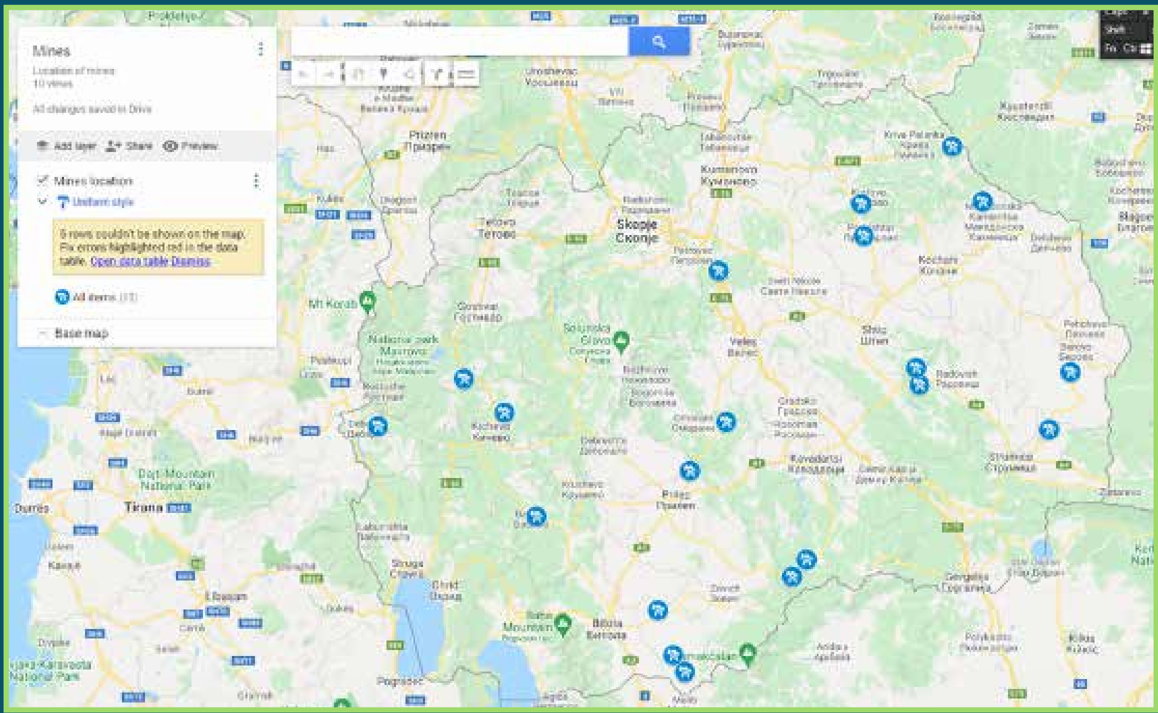

Figure 1. Initial map of mine locations

Having a list of possible sites for construction of wind or solar power plants means that there should be a methodology for prioritisation of these sites, which will determine which of these sites are suitable for such types of investment, and additionally which are the best sites not only in financial terms, but also legal, environmental, and social. In this regard, this study suggests the multi-criteria assessment methodology, where each location is evaluated through different criteria and the weights for each criterion are determined by using the Analytic Hierarchy Process method. One very important part of this methodology is the selection of criteria upon which the different sites will be graded, including the pre-assessment eligibility criteria. The process of selection of these criteria was complex and included the results of the legal and financial analyses conducted in this study, as well as the opinions of the different stakeholders which were very important in this process. Based on this, the following criteria were selected for the multi-criteria assessment process:

- power grid connection
- distance to road
- slope
- wildlife protection (birds, plants, etc.)
- qualified workforce that can be hired for the new investment
- proximity to settlements
- distance to rivers or lakes

- weather parameters (solar radiation and wind speed)
- type of land
- installed capacity

Additionally, for the project eligibility, the following criteria have been selected:

- Whether the project is consistent with valid EU policies and strategies
- Whether the project is covered by the relevant sector strategy paper (sector action plan or sector master plan)
- Whether the project contributes to valid national development objectives
- Whether the project is within protected areas
- The possibility for land acquisition and existing facilities
- Building permits

RESULTS

The methodology developed in this document is universal and is applicable not only for mines, but also for all other types of land, and especially intended for non barren land. Therefore, in this initial phase of the project five locations (mines) were selected, for which all of the necessary data were available (including pictures of the sites). However, in the next phase of the project this list of locations will be extended, and the same methodology will be applied. The results of applying the proposed methodology to these five locations show that the most suitable mine for PV construction is Suvodol, and the most suitable location for wind power plant construction is Sasa.

SUVODOL

This mine is located at a distance of 5 km from the nearest major settlement (Novaci). The location Suvodol is near the 400 kV transmission network. There is also a road next to the location. Using Google Earth it is determined that the average slope of the location is 10% (Figure 2), while using the Global Solar Atlas it is determined that global horizontal radiation is 1538.5 kWh/m^2, and the wind speed is 4.02 m/s. According to the Cadastre of the Republic of North Macedonia, this location is composed of cadastral parcels which are mostly barren land and pastures, and which are owned by the Power Plants of North Macedonia (ESM). The area of the site is about 6 km^2, on which about 450 MW PV can be installed. In terms of environmental protection, this location is not in a national park or protected area, or in an Important Plant Area (IPA); however, it is located in an Important Bird Area (IBA).

Figure 2.Slope calculation and road access using google earth - suvodol

According to the National Geoportal (http://nipp.katastar.gov.mk/), taking into account the hydrography, the Suvodolska River is located 500 m from the location, and there is no river at the site where the power plant would be built (Figure 3).

From the Employment Agency, the Survey of Unemployed Persons as of February 28, 2022 is used (https://av.gov.mk/content/Statisticki%20podatoci/%D0%A4%D0%B5%D0%B2%D1% 80% D1% 83% D0% B0% D1% 80% D0% B8% 202022 / p1_gradselo022022.xls.pdf), according to which the number of unemployed in Bitola (the city closest to the location) is 5 291.

Figure 3.River and lakes near to Suvodol, Cadaster of North Macedonia

BROD GNEOTINO

This mine is located at a distance of 12 km from the nearest major settlement (Novaci). The location Brod Gneotino is near the 110 kV transmission network. There is also a road next to the location (at about 260 m). Using Google Earth, it is determined that the average slope of the location is 4.5% (Figure 4), while using the Global Solar Atlas it is determined that global horizontal radiation is 1552.9 kWh/m^2, and the wind speed is 4.17 m/s. According to the Cadastre of the Republic of North Macedonia, this location is composed of cadastral parcels which are mostly barren land, pastures and fields and which are owned by the Power Plants of North Macedonia (ESM) and the Republic of North Macedonia. The area of the site is about 2 km^2, on which about 160 MW PV can be installed. In terms of environmental protection, this location is not in a national park or protected area, or in an IPA; however, it is located in an IBA.

Figure 4.Slope calculation and road access using google earth – Brod Gneotino

According to the National Geoportal (http://nipp.katastar.gov.mk/), taking into account the hydrography, a small lake is located near the site where the power plant would be built (Figure 5).

From the Employment Agency, the Survey of Unemployed Persons as of February 28, 2022 is used (https://av.gov.mk/content/Statisticki%20podatoci/%D0%A4%D0%B5%D0%B2%D1% 80% D1% 83% D0% B0% D1% 80% D0% B8% 202022 / p1_gradselo022022.xls.pdf), according to which the number of unemployed in Bitola (the city closest to the location) is 5 291.

Figure 5. River and lakes near Brod Gneotino, Cadaster of North Macedonia

PISKUPSTINA

This mine is located at a distance of 4 km from the nearest major settlement (Boroec). The location Piskupshtina is in the vicinity of the 110 kV transmission network. There is also a road next to the location. Using Google Earth, it is determined that the average slope of the location is 7.1% (Figure 6), while using the Global Solar Atlas it is determined that global horizontal radiation is 1469.4 kWh/m^2, and the wind speed is 4.1 m/s. According to the Cadastre of the Republic of North Macedonia, this location is composed of cadastral parcels which are mostly barren land, pastures and fields and which are owned by the Republic of North Macedonia and some private owners. The area of the site is about 0.11 km^2, on which about 9 MW PV can be installed. In terms of environmental protection, this location is not in a national park or protected area, or in an IBA; however, it is located close to an IPA.

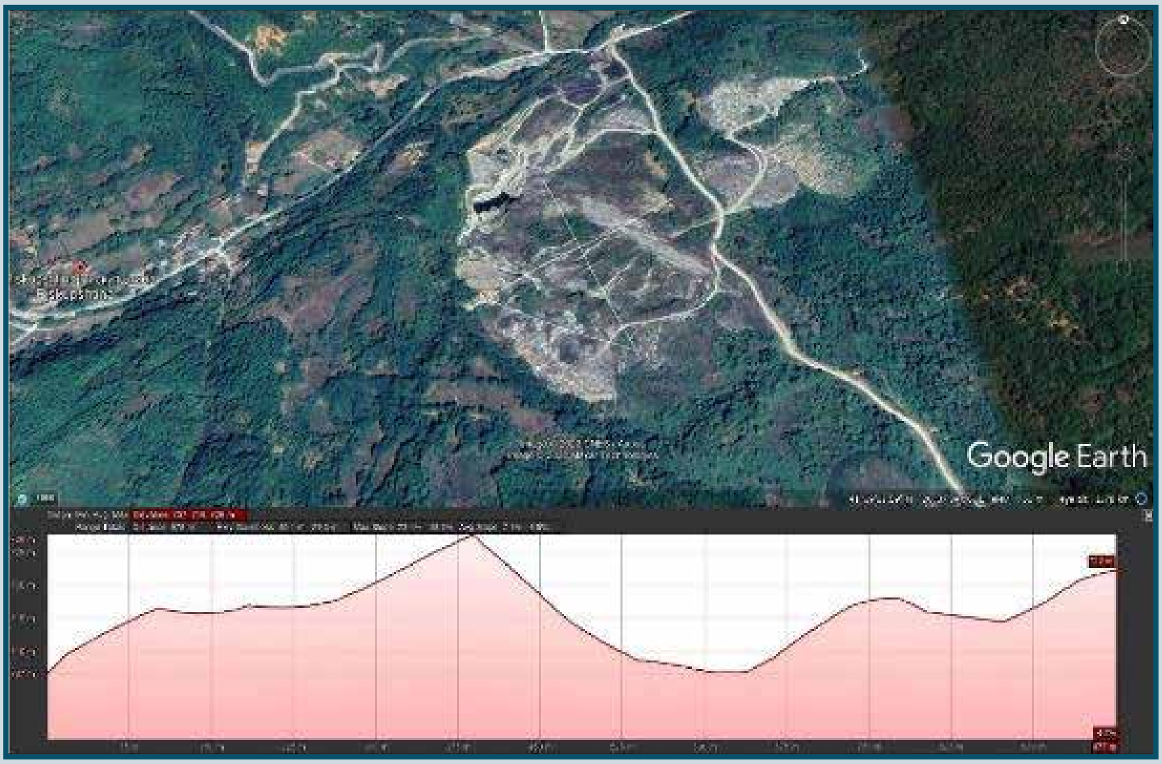

Figure 6.Slope calculation and road access using google earth – Piskupstina

According to the National Geoportal (http://nipp.katastar.gov.mk/), taking into account the hydrography, the river Volneshki Trapoj, as well as one other river, is located at the place where the power plant would be built (Figure 7).

From the Employment Agency, the Survey of Unemployed Persons as of February 28, 2022 is used (https://av.gov.mk/content/Statisticki%20podatoci/%D0%A4%D0%B5%D0%B2%D1% 80% D1% 83% D0% B0% D1% 80% D0% B8% 202022 / p1_gradselo022022.xls.pdf), according to which the number of unemployed in Struga (the city closest to the location) is 3 660.

Figure 7.River and lakes near to Piskupstina, Cadaster of North Macedonia

SASA

This mine is located at a distance of 10 km from the nearest major settlement (Makedonska Kamenica). The location Sasa is in the vicinity of the 110 kV transmission network. There is also a road next to the location. Using Google Earth, it is determined that the average slope of the location is 11% (Figure 8), while using the Global Solar Atlas, it is determined that global horizontal radiation is 1270.2 kWh/m^2, and the wind speed is 6.9 m/s. According to the Cadastre of the Republic of North Macedonia, this location is composed of cadastral parcels which are mostly artificially barren land, owned by the Republic of North Macedonia and Sasa. The area of the site is about 0.10 km^2, on which about 8 MW PV can be installed. In terms of environmental protection, this location is not in a national park or protected area, or in an IBA or IPA.

Figure 8.Slope calculation and road access using google earth – Sasa

According to the National Geoportal (http://nipp.katastar.gov.mk/), taking into account the hydrography, the river Kamenica as well as one other small lake is located at the place where the power plant would be built (Figure 9).

From the Employment Agency, the Survey of Unemployed Persons as of February 28, 2022 is used (https://av.gov.mk/content/Statisticki%20podatoci/%D0%A4%D0%B5%D0%B2%D1% 80% D1% 83% D0% B0% D1% 80% D0% B8% 202022 / p1_gradselo022022.xls.pdf), according to which the number of unemployed in Kocani (the city closest to the location) is 2 785.

Figure 9.River and lakes near to Sasa, Cadaster of North Macedonia

DAMJAN

This mine is located at a distance of 10 km from the nearest major settlement (Radovish). Damjan is around 3 km from the 110 kV transmission network. There is a road next to the location. Using Google Earth, it is determined that the average slope of the location is 7.6% (Figure 10), while using the Global Solar Atlas, it is determined that global horizontal radiation is 1513.4 kWh/m^2, and the wind speed is 5.76 m/s. According to the Cadastre of the Republic of North Macedonia, this location is composed of cadastral parcels which are mostly owned by the Republic of North Macedonia. The area of the site is about 0.09 km^2, on which about 7 MW of PV can be installed. In terms of environmental protection, this location is not in a national park or protected area, or in an IBA or IPA.

Figure 10.Slope calculation and road access using google earth – Damjan

According to the National Geoportal (http://nipp.katastar.gov.mk/), taking into account the hydrography, one lake is located at the place where the power plant would be built (Figure 11).

From the Employment Agency, the Survey of Unemployed Persons as of February 28, 2022 is used (https://av.gov.mk/content/Statisticki%20podatoci/%D0%A4%D0%B5%D0%B2%D1% 80% D1% 83% D0% B0% D1% 80% D0% B8% 202022 / p1_gradselo022022.xls.pdf), according to which the number of unemployed in Radovish (the city closest to the location) is 2 491.

Figure 11.River and lakes near to Damjan, Cadaster of North Macedonia

RESULTS FROM PRIORITISATION OF CANDIDATE SITES

The results from the prioritisation are based on the calculated and evaluated data for each of the analysed locations, given in Table 1.

TABLE 1. INPUT DATA FOR THE PRIORITISATION

	SUVODOL	BROD GNEOTINO	PISKUPSTINA	SASA	DAMJAN
Power grid connection (kV)	400, almost on the site	110, almost on the site	110	110, almost on the site	110, on 3 km
Distance to road (m)	130	260	1	1	110
Slope (Average)	10	4.4	7.1	11	7.6
Wildlife protection	birds	birds	No, birds	No, birds	No, birds
Workforce	5291	5291	3660	2785	2491
Proximity to settelements (km) vozdusno	5	12	4	10	10
Distance to rivers or lakes	500	0	0	0	0
Solar radiation (kWh/m2) (GHI)	1538.5	1552.9	1469.4	1270.2	1513.4
Wind speed (m/s)	4.02	4.17	4.1	6.9	5.76
Type of land, owner	Barren, ESM	Barren, ESM and Republic of North Macedonia	Barren, Republic of North Macedonia, private	Barren, Republic of North Macedonia, SASA	Barren (stonecutter) Камењари, Republic of North Macedonia
Installed capacity (km2)	6	2	0.11	0.10	0.09
Solar installed capacity (MW)	480	160	9	8	7

The wind speed at the locations of the mines Suvodol, Brod Gneotino and Piskupshtina is around 4 m/s which is lower than the minimum needed for construction of wind power plants, so these locations were not considered. The results of the other two locations are shown in Table 2. It can be noticed that the location of Sasa is more suitable for wind power plant construction since, according to the measured wind speed, it has a higher value, and therefore a higher score. The results of the weights for each criterion, based on the experts' opinions, are also presented in Table 2.

TABLE 2. RESULTS OF THE PRIORITISATION OF LOCATIONS FOR WIND POWER PLANTS

	SASA	DAMJAN	WEIGHT OF CRITERIA
Power grid connection (kV)	5	5	15%
Distance to road (m)	5	5	6%
Slope (Average)	3	3	8%
Important bird area	5	5	10%
Workforce	1	1	7%
Proximity to settlements (km)	1	1	7%
Distance to rivers or lakes	1	1	7%
Wind speed (m/s)	5	4	16%
Type of land	5	5	16%
Installed capacity (km2)	1	1	8%
FINAL SCORE	**3.68**	**3.52**	

The results for the prioritisation of the solar power plants are shown in Table 3. It can be noticed that the most suitable location is Suvodol, because of the great solar radiation at the location, the large area on which the solar panels can be installed, as well as the advantage related to the hydrology in the location (since there is no river or lake at the location, as is the case for the other locations).

TABLE 3. RESULTS OF THE PRIORITISATION OF LOCATIONS FOR SOLAR POWER PLANTS

	SUVODOL	BROD GNEOTINO	PISKUPSTINA	SASA	DAMJAN	WEIGHT OF CRITERIA
Power grid connection (kV)	5	5	5	5	5	15%
Distance to road (m)	5	5	5	5	5	6%
Slope (Average)	3	5	3	3	3	8%
Important plant area	5	5	5	5	5	10%
Workforce	5	5	3	1	1	7%
Proximity to settlements (km)	3	3	3	1	1	7%
Distance to rivers or lakes	5	1	1	1	1	7%
Solar radiation (kWh/m2) (GHI)	5	5	4	1	5	16%
Wind speed						
Type of land	5	5	5	5	5	16%
Installed capacity (km2)	5	2	1	1	1	8%
FINAL SCORE	**480**	**160**	**9**	**8**	**7**	

From the obtained results it can be concluded that the tested sites have a great potential for the construction of solar power plants. On the other hand, in terms of capacity for construction of wind farms, only one location stands out, but that location is with minimum wind potential because the wind speed is just over 6 m / s.


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