

POSSIBILITY OF INSTALLATION OF SOLAR POWER PLANTS IN EXPLOITATION SITES

Branimir Farkaš^{1#}, 0000-0002-2377-9446,

Ana Hrastov², 0009-0003-9087-4413,

Iva Štefičar², 0009-0003-9735-5675,

¹Faculty of Mining, Geology and Petroleum Engineering, Zagreb, Croatia

²RUDAR PROJEKT d.o.o., Zagreb, Croatia

ABSTRACT – In response to increasing energy demands, driven by the constant need for energy commodities, a strategic shift towards adopting alternative renewable energy is today's reality. In pursuit of enhancing the efficacy of renewable energy production, with a primary focus on solar energy, the idea of using mineral exploitation fields as prospective domains for solar power plant deployment has emerged. These sites span from tens to hundreds of hectares and are presenting opportune terrains for the installation of large-scale solar infrastructure.

To underscore the potential for multifunctional spatial utilization and the augmentation of solar energy integration, this research undertakes a comprehensive analysis encompassing legislative frameworks and technological modalities governing the integration of solar power facilities within exploitation fields. Drawing upon this analysis, different variants and models for solar power plant installation are presented.

Keywords: Exploitation Fields, Renewable Energy, Solar Power Plants.

INTRODUCTION

Due to the increasing demand for energy products, we are rapidly turning to alternative renewable sources of energy production. To increase the possibility of producing energy from renewable sources compared to the current situation, and primarily the use of solar energy, exploitation fields of solid mineral raw materials were considered as potential areas for the installation of solar panels (SP) due to the large areas they occupy, from several tens to hundreds of hectares. In this way, exploitation fields can be used for multiple purposes, exploiting mineral resources and producing renewable electric energy using SPs.

Various authors have considered the possibility of using the space of abandoned open-pit mines, where the exploitation of mineral raw materials has ended, to produce electricity from renewable sources [1,2]. Heib (2022) analyses, in his paper, the advantages and disadvantages of installing solar systems in landfills created by the disposal of mine waste from coal exploitation [3]. Given that there is a great need for energy sources during the operation of machinery in open-pit mines, the authors Igogo et. al. (2021) and Whitbread-Abrutat et. al. (2011) in their papers deal with the

[#] corresponding author: branimir.farkas@rgn.unizg.hr

integration of renewable energy sources (sun, wind, etc.) into the exploitation processes or conversion of the mining works area after the completion of exploitation works [4,5].

To point out the possibility of this way of managing space in the Republic of Croatia and increasing the use of solar energy, this paper has conducted an analysis that includes legislative frameworks and technical possibilities for the location of solar power plants (SPPs) within the area of exploitation fields. Based on the analysis, proposals for different Variants for the installation of SPPs and Electricity Utilization Models were given, as well as a proposal for optimal areas where it would be possible to install SPPs.

EXPERIMENTAL

For the possibility of multipurpose use of mining sites, i.e. for the simultaneous exploitation of mineral resources and the installation of SPPs, it is necessary to analyse numerous different data. This includes the spatial data of the Ministry of Economy [6] on exploitation fields and legal acts regulating the issue of exploitation of mineral resources, as well as those regulating the use of renewable energy sources and the installation of SPPs. Based on the analysis of the above, proposals for variant solutions for the installation of SPPs within the mining sites were given, as well as proposals for the need to amend the law.

Analysis of law provisions

Mining sites on which the exploitation of mineral resources is currently conducted or has been carried out are considered as a proposal for possible locations for the installation of SPPs, legal legislation in the field of mining, spatial planning, construction, environment, and energy have been analysed. Figure 1 shows the above-mentioned legal areas and highlights the most important laws, ordinances, and/or regulations, as well as some of the documents or procedures that need to be implemented to carry out the exploitation or installation of SPs.

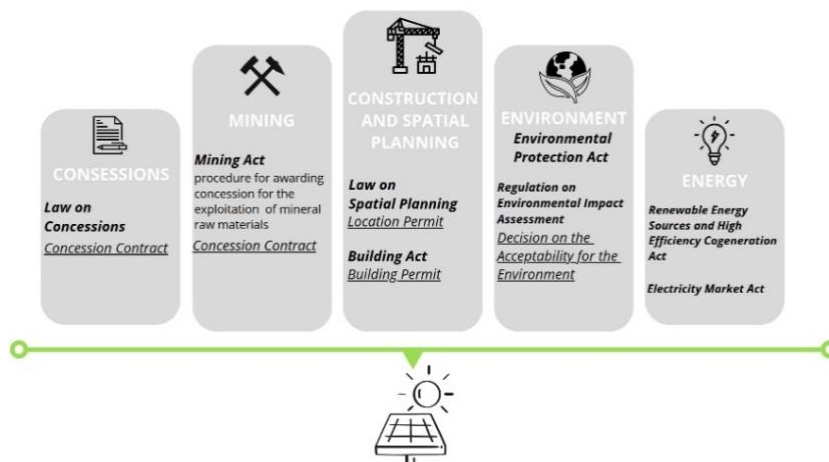
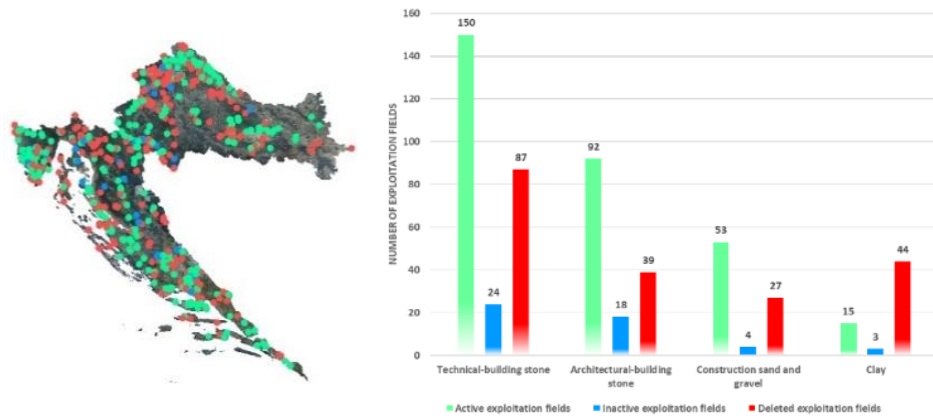


Figure 1 Law provisions for the possibility of installing SPP [7]

Analysis of technical possibilities of installing solar power plants at mining sites

According to the data of the Ministry of Economy and Sustainable Development [6], there are a total of about 800 exploitation fields in the Republic of Croatia, which includes active, inactive, and closed exploitation fields (Figure 2a). The mineral raw materials that are the most exploited are: technical-building stone, architectural-building stone (block and slab), construction sand and gravel, and clay (brick clay, bentonite, ceramic, and fire-resistant clay). Figure 2b shows the number of exploitation fields depending on the activity for the above-mentioned mineral raw materials.



a) Exploitation fields in the Republic of Croatia b) Distribution of exploitation fields by mineral raw materials and activity

Figure 2 View of exploitation fields and the most exploited mineral raw materials [6]

The technical possibilities of installing SPs within exploitation fields depend primarily on the type of mineral raw material that is exploited (concerning different exploitation technologies) and on the geometry of open-pit mines that occur due to exploitation [7].

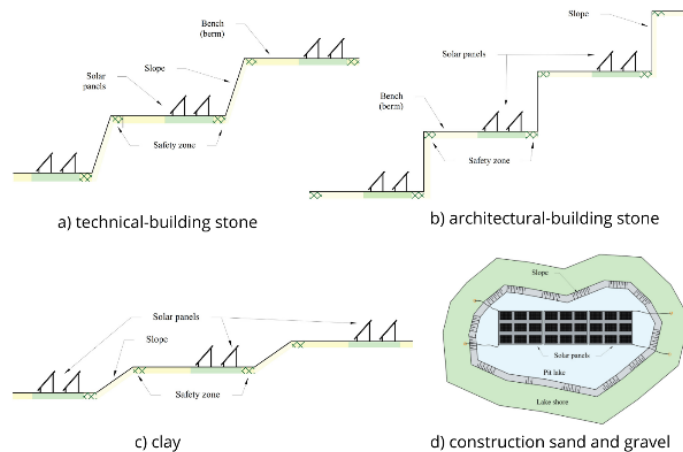


Figure 3 Possibility of placing SPs depending on the geometry of open-pit mines [7]

Surfaces that can be used for the placement of SPs are benches (berms) created by the exploitation of technical-building and architectural-building stone and clay (Figures 3a, 3b, 3c). The exploitation of these mineral raw materials is performed by drilling and blasting (technical-building stone), sawing blocks with a chain saw or diamond wire saw (architectural-building stone), or, in the case of clay exploitation mechanized – with excavators. In the exploitation of construction gravel and sand, dredgers are used, and consequently, water surfaces (lakes) are created that are suitable for the installation of floating SPs (Figure 3d).

RESULTS AND DISCUSSION

Based on the analyses [7], variant options for locating SPPs in open-pit mines have been proposed depending on the dynamics of mining operations (Variant 1, Variant 2, and Variant 3) and depending on electricity consumption (Model 1, Model 2, Model 3). The analysis of the legislative frameworks covering the exploitation of mineral raw materials in the Republic of Croatia and the production of energy from renewable sources has given suggestions for possible changes that would need to be implemented to enable the multipurpose use of the mining sites.

Proposal for necessary legal changes

The multipurpose use of mining sites requires the harmonization of several different areas of law, it is necessary to make some changes to them. To make this possible, it is needed to process or resolve issues that arise during the installation of SPPs in areas intended for the exploitation of mineral resources through legal legislation. For the harmonization of laws, i.e. their amendment, it is necessary to do the following [7]:

- harmonize spatial planning documentation,
- resolve property rights,
- designate the ministry responsible for issuing building permits,
- specify the allowed location of the SPP installation at mining sites,
- elaborate the installation of the SPP in a mining project,
- implementation of the environmental impact procedure,
- include the possibility of installing the SPP in the exploitation field in the concession obtaining procedure,
- tender conduction for secondary activity (establishment of the SPP at mining sites for which the concession fee is already paid).

Variants solutions for the placement of SPPs in exploitation fields

Variants of SPP installation depending on the dynamics of mining works

Depending on the dynamics of mining works performance, there are three possible variants of SP installation (Figure 7), whose positions within the boundaries of the exploitation field can be temporary or permanent.

Variants that occur depending on the dynamics of mining works are:

- Variant 1 – installation of SPs before awarding a concession for the exploitation of mineral raw materials (Figure 4a) – use of mobile solar panels,
- Variant 2 – installation of SPs during the mining works performance with a concession for the exploitation of mineral raw materials (Figure 4c) – use of fixed and mobile SPs,
- Variant 3 – installation of SPs after the completion of mining works (Figure 4b) – use of mobile SPs.

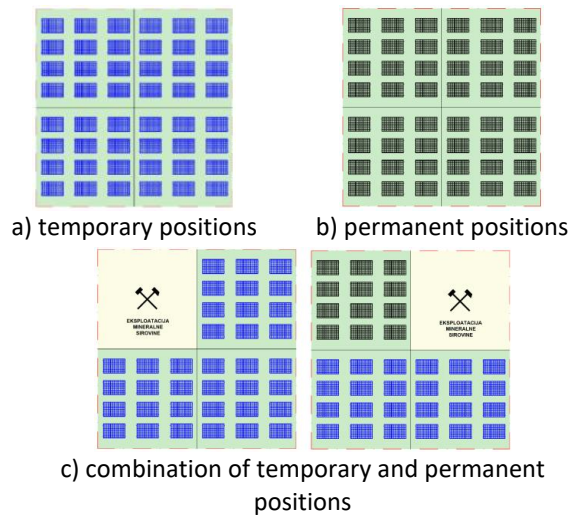


Figure 4 Possibility of placing SPs depending on the dynamics of mining works [7]

Models of Electricity Usage

Each exploitation field on which mining works are carried out i.e. the exploitation of mineral raw materials in its technological process depends on some type of energy source (diesel fuel, electricity from the distribution network, or generators). All these forms of energy that are needed for a mining site to function can be efficiently replaced by electricity produced by SPPs located at mining sites.

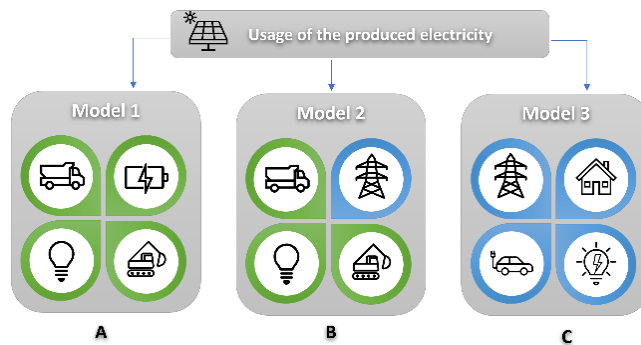


Figure 5 Models of electricity usage [7]

Depending on the needs within the exploitation field and the method of electricity delivery, SPPs can be divided into three models (Figure 5):

- Model 1 – the entire electricity produced is used for the needs of the exploitation field,
- Model 2 – the produced electricity is partly used for the needs of the exploitation field, and the surplus is handed over to the electricity grid,
- Model 3 – all electricity produced is handed over to the electricity grid for further distribution.

CONCLUSION

Multipurpose use of mining sites represents an integrated way of space planning that is not fully regulated by current legislation. By installing SPPs within the boundaries of exploitation fields, it would be possible for the authorized person/concessionaire to reduce its energy needs (electricity from the distribution system, diesel fuel, etc.) to a minimum or become completely energy-independent. Energy independence would enable a reduction in the price of mineral aggregates on the market, which would result in a decrease in the prices of construction of new buildings. In addition, the usage of electric mining machinery would completely nullify the harmful exhaust by-products of diesel fuel combustion in the engines of mining machinery and would significantly reduce the impact on the environment.

REFERENCES

1. Mert, Y. (2019) Contribution to Sustainable Development: Re-Development of Post-Mining Brownfields. *J Clean Prod*, 240.
2. Kim, H., Ku, J., Park, H.-D. (2021) Analysis of Photovoltaic Potential of Unused Space to Utilize Abandoned Stone Quarry. *Tunnel and Underground Space*, 31, 534–548, doi:<https://doi.org/10.7474/TUS.2021.31.6.534>.
3. Heib, M. (2022) AI ASSESSMENT OF ADVANTAGES AND LIMITATIONS OF INSTALLING PV ON ABANDONED DUMPS. *Surface Mining*.
4. Igogo, T., Awuah-Offei, K., Newman, A., Lowder, T., Engel-Cox, J. (2021) Integrating Renewable Energy into Mining Operations: Opportunities, Challenges, and Enabling Approaches. *Appl Energy*, 300.
5. Whitbread-Aburatat, P., Coppin, N. (2011) Exploring Alternative Energy Options for Mine Sites. In *Proceedings of the Sixth International Conference on Mine Closure*; Australian Centre for Geomechanics, pp. 559–568.
6. MINGO JISMS - WebGis Portal. Unified information system for mineral resources 2024. – (*In Croatian: Jedinstveni informacijski sustav mineralnih sirovina*).
7. Farkaš, B., Hrastov, A. (2023) Analysis of the Legislative Framework and Technical Possibilities of Placing Solar Power Plants on the Areas of Exploitation Fields of Solid Mineral Raw Materials – (*In Croatian: Analiza Zakonodavnog Okvira i Tehničke Mogućnosti Smještaja Solarnih Elektrana Na Prostore Eksploatacijskih Polja Čvrste Mineralne Sirovine*).