INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ACCOUNTING, FINANCE AND MANAGEMENT SCIENCES

OPEN ACCESS JOURNAL

Vol 14, Issue 1, (2024) E-ISSN: 2225-8329

Comparative Financial Analysis of the Return on Investment in Solar Energy Projects on the Federation of Bosnia and Herzegovina Market

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To Link this Article: http://dx.doi.org/10.6007/IJARAFMS/v14-i1/20639 DOI:10.6007/IJARAFMS/v14-i1/20639

Published Online: 25 January 2024

Abstract

Investment in solar energy is a very current and underexplored topic, especially if the research questions are focused on the territory of Bosnia and Herzegovina Federation (FBiH). In FBiH, there is certainly interest in investing in solar energy projects but the key to making the final decision to invest includes determining the profitability of solar power plants and determining whether investment in these projects is cost-effective. This paper aims to determine the return on investment (ROI) in solar energy projects in FBIH using empirical data and adequate analyses. A case study as a widely applied research strategy within the qualitative methodology was used and 162 scenarios were created for three selected locations in FBiH (Bjelašnica, Bihać-Željava and Livanjsko polje- the Livno Field). The case study inputs point to a cautious approach to the potentials of investment risk in this type of venture in FBiH, since a discount rate of 10% was set, which is mostly, but not exclusively, higher than the discount rates used in other countries. With such an attitude to risk, i.e., a cautious approach to the potentials of investment risk potentials and the postulated hypotheses, the results showed that solar power plants (SPPs) are much more profitable in the case when the producer is in the incentive system. Still, even with such a defined eligibility threshold of ROI, there are scenarios that point to the possibility of profitable business without incentives.

Keywords: Financial Analysis, Solar Energy, Case Study, Federation of Bosnia and Herzegovina

Introduction

For decades, the world has been running on fossil fuels but technology advancement opened up new possibilities. Fuels that pollute the environment ceased to be the only option for electricity production years ago. Renewable energy sources (RES) - sun, wind power, water power, geothermal energy, and biomass are becoming more and more common in electricity production worldwide, including the European Union (EU). However, due to the dominance of fossil fuels in electricity production, both in the world and in the EU, one can easily assume that the reason for this lies in greater profitability and the fact that fossil fuels are cheaper. This was true in the past but it is no longer the case. Actually, the world and the EU are well

aware of this fact, and with their policies and programs they are working on the transition to RES.

Investment into SPPs is attractive due to the following dimensions: increase in environmental awareness, constant growth of the need for electricity, the fact that solar energy is free and unlimited, the fact that solar power plants do not make noise and do not pollute the environment, and minimum maintenance costs. An additional dimension is the constant technological advancement that changes economic aspects in the context of cutting down the costs of investment in solar power plants. As technology advances, the price of solar panels and other equipment needed to build a solar power plant is constantly on the decrease, thus making wind and solar power plants cheaper than any other fossil fuel power plant.

There are several reasons that motivate the research into financial return on investment (ROI) into solar power plant projects in Federation of Bosnia and Herzegovina (FBiH). They include: an evident increase in the popularity of the construction of solar power plants, a huge interest in investing in this type of electricity production, a constant increase of fees for RES, a drastic drop in investment costs due to the drop in prices of parts of solar power plants, a projected growth of competitiveness compared to other power plants, the results of numerous studies on the markets of other countries, as well as the lack of similar research in Bosnia and Herzegovina (BiH). The primary research goal of this paper is to analyze, based on theoretical and empirical findings, whether solar power plants in FBiH are sufficiently profitable, i.e., whether and under which conditions they provide an adequate internal return rate for investors.

Theoretical preliminaries the analysis of financial return on investment in solar power plant construction and business: research overview

Investigating the ROI into of SPPs was the subject of numerous researches that used case studies as their research methods. This qualitative methodological approach to the ROI in SPPs is indeed rather frequent. The research paper by Benković (2021) needs to be mentioned. Published in the neighboring Croatia, it dealt with the specificities of budgeting the capital for SPPs investment projects in Croatia. The construction of a 2.4 MW (2400 kW) SPP in Dalmatia was selected for the analyzed investment project. The methods of financial decision-making showed that the investment project was cost-effective. The initial assumptions were determined: the investor decided to buy the land, due to which it was not necessary to obtain a location permit. The total investment costs were estimated at approximately €1,800,000 or in other words the cost per unit of installed power was €757/kWp. The operating costs were used in the calculation, which included regular and immediate maintenance and management of the power plant, compensation costs to the local community, and other unforeseen costs. In addition to the operating costs, there were also maintenance costs estimated based on the existing experiences and available literature for similar projects in Croatia and worldwide at €5 per kW. Other unforeseen costs were estimated at 5% of all other operating costs. It was assumed that the construction project would be fully financed by the investor's equity. The author set the amortization period at 10 years. The standard assumption for solar panel lifetime is 25 years. The ROI analysis was made for 12 years as in the 13th year additional investments would be needed for the inverter replacement. The discount rate, i.e., the cost of capital, was estimated at 7.08%, and annual panel degradation was estimated at 0.4%. A more detailed analysis was not used to determine the interest rate. The methods of financial decision-making used in this paper were pure

present value, internal rate of profitability, profitability index, modified internal rate of profitability, and PP (Benković, 2021).

A similar study was made in Poland the same year (Niekurzak and Kubinska-Jabcon, 2021). Using the Global Solar Atlas online application, the solar radiation in Poland was estimated and the net present value (NPV) was calculated for the period of 20 years. The model used return on assets to come to the conclusion. The assumptions were made for the costs, utilization, etc., and the discount rate was assumed to be 5%. The efficiency of solar panels was estimated at 0.77, and with the conditions on the Polish market, the PP was eight years with the NPV of €6,000 for an investment cost of €4,500.

Another example of a case study for solar power plants is the 2020 study in which the authors analyzed the profitability and discount rate for the solar power plants in Spain (Guaita-Pradas and Blasco-Ruiz, 2020). This author also conducted a financial analysis for solar power plants in the Ivory Coast using a case study. A 20kW solar power plant was taken into account, and after assessing the appropriate location and assumed investment costs based on earlier research and market data, the calculations were made for NPV, internal rate of return (IRR) and payback period (PP). The result for the PP was six years. Certain macroeconomic assumptions had to be made for the calculations: inflation, maintenance, etc. The resulting IRR was 15.2% (Guaita-Pradas et al., 2015).

Also, it is interesting to compare the results of scientific research conducted in completely different geographical areas. Using the HOMER Energy software fed by technical data and macroeconomic assumptions, the PP of 10.78 years and the IRR of 7.88% were calculated for Norway (Gholani and Røstvik, 2021). On the other hand, in a sunny country such as Nigeria using the RETscreen software and estimated investment costs as well as the estimated discount rate of 7%, the calculations were made for the IRR of 22% and the PP between 3.7 and 5.2 years (Hamisu-Umar et al., 2021).

Other authors compared the profitability of solar power plants for the European countries. Prol (2018) commented in details the incentive system in Spain and Germany (Prol, 2018). The master's thesis by the Croatian author Briški (2020) also needs to be mentioned, in which a case study was conducted for a different form of renewable energy. Namely, the author analyzed the profitability of wind farms and incentives in Croatia. The analysis was made of 13 wind farms that went into operation in the period from 2009 to 2013, and the calculations were made for the levelized cost of electricity (LCOE) and the weighted average cost of capital (WACC), which consists of the cost of equity capital (investment costs) and the cost of debt (interest rates on long-term liabilities). The author identified the WACC for wind farms of 7.5% to 8.5% for Croatia. The study also assessed the interest rate, risk premium, etc. (Briški, 2020).

A very important study was made as a part of the master's thesis (Westén, 2019) on the profitability of large solar power plants in Sweden. A case study was made at three locations; geographical and climate data were collected, and solar radiation and potential solar energy (SE) power were calculated for potential locations. Investment costs were obtained from recent reports. The LCOE was calculated, which represents the total cost per consumed kWh for the entire life of the project. Incentives for RES available in Sweden were up to 20% of investment costs. The costs were estimated and the discount rate was set at 6.25% (Westén, 2019).

Another study, important for this research, was the one conducted in Italy Cucchiella et al (2016), which examined if solar power plants are cost-efficient without incentives. The study aimed to examine their profitability using NPV, PP, pollution reduction in SE without

incentives. The study assumed investment costs as well as the estimates of technical characteristics and macroeconomic indicators according to the data from the literature. The calculations were made for the profitability of 3kW, 6kW and 20kW solar power plants. The solar power market in Italy is a mature market with highly reduced investment costs and removed incentives. The results showed that small solar power plants in Italy are profitable without incentives in almost all cases. The PPs calculated were four and six years (Cucchiella et al., 2016).

What was also useful for the designing of the case study presented in this paper was the work of Bago (2012) in which he evaluated the insolation in BiH as well as the data of the Center for Investigative Reporting on the existing incentives. It is also interesting that the European Court of Auditors found that within the initial support programs, excessive subsidies were provided for the introduction of wind energy and solar photovoltaic energy, but also that the reduction in the level of support led to a deterrent from potential investments (the European Court of Auditors, 2019). Similar research, focused on the insolation of BiH with the calculation of LCOE, was conducted for renewable sources in BiH. It concluded that the operation of solar power plants is profitable without incentives (Miljević, 2020).

Calculations of investment costs for solar power plants were made by many other authors, such as Shetty and Kulkarani (2014), who made the estimates for a 500 kW plant as well as Tomić and Kučko (2013), who estimated the investment costs for a 10 kW solar power plant in Croatia at the value of €50,700 with no credit financing or approximately €88,600 with credit. The profitability of solar power plants was also investigated by Bajrić (2013), who expanded the techno-economic analysis of photovoltaic systems with a profitability analysis, Cvrk (2011), who was interested in optimizing the use of solar energy through photovoltaic conversion, and certainly by Komorski (2018) through his description of the operation of the 1MW photovoltaic power plant.

All this clearly points to the presence and popularity of a qualitative methodological approach, i.e., simulating scenarios and creating various studies of financial analysis of the profitability of building and operating solar power plants around the world. Including the results of the aforementioned research as well as various methodologies, the financial analysis was designed to be used for the case study in FBiH.

Research Methodology

A case study is a widely applied research strategy within the qualitative methodological approach. The Fractal Split Solar program, developed by the company Fractal Ltd (Fractal d.o.o.) from Split, Croatia, was used for the financial analysis of the return on investment in construction and operation of the solar power plant. This is a consulting company in the field of RES. Fractal Split Solar is a completely free software available at the company's website.

Using a case study as a qualitative methodological approach and applying the carefully selected inputs for conducting the financial analysis, the main research hypothesis is to be tested

H_1: There is return on investment in solar energy projects on the market of FBiH

The central goal of this paper is to determine whether there is return on investment in solar power plants in terms of profitability of construction and operation, as well as the PPs for solar power plants at selected potential locations, by simulating the scenarios with and without incentives. Given there are different types of power plants, different financing

methods, as well as different locations for their installation, the results will be presented in a way to meet the following operational goals of the paper:

- Rank investment projects by types of solar power plants (present the case analyses for micro (15 kW), mini (100 kW), and small (500 kW) solar power plants),
- Rank investment projects in solar power plants by potential locations,
- Rank investment projects in solar power plants by different types of financing,
- Compare and interpret the results.

Inputs for financial analysis**:** the analysis includes the input of the technical parameters of the projects, the method of financing the project (the credit share in the investment as well as the data on the credit), and income tax and depreciation. Also, income calculation requires the data on the price of electricity for the incentive-covered period as well as the subsequent period when the reference prices apply. The total investment costs are formed as the sum of costs for solar panels, inverters, construction, site development, construction works and foundations, assembly, electrical equipment, grid connection, documentation and preparation, potential land purchase and unforeseen costs. Operational costs include incidental costs, potential land lease costs, and maintenance and insurance costs. The outputs of the financial analysis are the project NPV, IRR, PP, and benefit/cost ratio (BCR).

Solar power plants consist of: (1) solar panels that can be placed on roofs, parking lots, water bodies or unusable agricultural land, (2) an inverter that converts the voltage from DC to AC, and (3) a counter through which the produced electricity is sent to the grid. The inputs used in the financial analysis as a part of the case study are based on an extensive market research and a large number of previous studies that used the same or similar methods of calculating NPV, IRR, PP, and BCR. The basic technical parameters of the project include the capacity of the solar power plant (15 kW, 100 kW, 500 kW), the annual production of electricity that depends on the location and the installed capacity, available on the Global Solar Atlas, and also the panel degradation assumed as in Benković (2021) at 0.4%.

Table 1
Basic technical parameters for SPPs 15 kW, 100 kW, 500 kW on the locations Bjelašnica, Bihać-Željava and Livanjsko polje

		Micro SPPs	Mini SPPs	Small SPPs
Solar power plant capacity		0.015 MW	0.1 MW	0.5 MW
Annual production of electricity	Bjelašnica	19.56 MWh	130.42 MWh	652.08 MWh
	Bihać-Željava	17.32 MWh	115.48 MWh	577.39 MWh
	Livanjsko polje	19.78 MWh	131.87 MWh	659.33 MWh
Panel degradation		0.40%	0.40%	0.40%

Source: Authors' calculation using the Global Solar Atlas, 2021.

The financing of the project described in this paper depends on the set scenario. Three scenarios were created: (1) 100% credit financing, (2) 50% credit, and (3) 100% equity capital. When forming credit maturity of 12 years and the interest rate of 3%, the market data were taken, with corrected by maximum conservatism against risk. When estimating the discount rate, the work by Sabolić (2018) was also used, in which he discussed various risks that form the final return rate. The results of a large-scale survey (Grant Thornton, 2019) which provided the data on average discount rates for solar power plants around the world were also indispensable. For example, the discount rate for solar power plants in Italy was from 6.25%

to 8%, in Germany it was from 4.26% to 5.25%, in France from 5% to 6.25%, in rainy Ireland from 5.50% to 8%, etc. As a part of his postgraduate thesis, Benković set a discount rate of 7.08% in Croatia for his case study

The Economic trends – annual reports of the BiH Directorate for Economic Planning (2020) served as an insight into the macroeconomic indicators needed for business risk assessments in BiH. Compared to the EU member states, BiH, as a non-EU member has greater risks of specific macroeconomic conditions in the country, investors' risks as well as the sector risk. Taking into account all of the above as well as the additional conservative approach, the assumed discount rate for BiH is 10%. In accordance with the Law on Income Tax, the prescribed rate of 10% was used in the study.

Table 2
Financing the project of SPPs 15 kW, 100 kW, 500 kW on locations Bjelašnica, Bihać-Željava and Livanjsko polje

Discount rate	10%
Financing	100% credit, 50% credit, 0% credit
Credit maturity	12 years
Interest rate	3%
Income tax	10%

Source: Authors' calculation, 2021.

The lifetime of the solar power plant project in the majority of previous studies was set at 25 years. BiH is not an exception, the incentive period lasts 12 years, after which more favorable reference prices apply. The guaranteed and reference prices were specified by the Operator for renewable sources and efficient cogeneration. It is important to mention that the BAM/€ exchange rate was taken into account, and the prices were converted to € to be consistent with the rest of the input.

Table 3
Guaranteed and reference prices in the study for FBiH

	Reference price	Guaranteed price
Micro SPP	0.112211	0.29063
Mini SPP	0.112211	0.22341
Small SPP	0.112211	0.17716

Source: Decision on issuing the approval to guaranteed purchase prices of electricity from plants for the use of renewable energy sources and efficient cogeneration, 2021.

The total investment costs differ according to the size of the solar power plants, although certain costs such as the costs of obtaining documentation were identical for all three types. The documentation costs were taken from Tiro (2017) and amount to €4,500 €. Certain sources indicated the total investment costs for the construction of a solar power plant in BiH from €1,250 to €1,750 per kW (Partner Microcredit Organization: Energy Efficiency). Other sources pointed out that the low share of solar power plants in BiH is due to, among other things, high capital costs of €450 to €750 per m2 when using solar energy for heating (Regional Center for Education and Information on Sustainable Development for South-East Europe). Infinite Energy estimated the investment costs required for the

construction and operation of a 100 kW SPP at €120,000. The Fraunhofer Institute for Solar Energy (2020) estimated the 2020 investment costs for SPPs of a 719/kW.

The Guide for investors in the electricity sector in BiH (USAID, 2018) was extremely useful for the analysis in this case study. The Guide explains the responsibilities of institutions and bodies for the energy sector in BiH as well as the process of connecting to the grid, and lists all the permits required for starting a SPP. In 2017, Fu et al. quoted the price of solar panels as €0.32/W, while in 2010 the price was €1.85/W. The International Renewable Energy Agency- IRENA, on the other hand, announced in its 2019 publication that solar panel prices in Europe in 2018 were between €0.20/W and €0.40/W. The Super PV listed the prices of solar panels in 2018 from €0.10/kWh to €0.30/kWh. When forming the panel price of 300 €/kW, which is also equal to 0.3 €/W, all the mentioned data were taken into account so that the obtained price was realistic.

The price of the inverter was formed based on the data by Clissitt (2020), quoted between €600 and €1,200 for roof installations, while Energy Five (2017) stated the cost of approximately €90,000 for a 500 kW solar power plant. Also, it was stated that the costs for the inverter and the structure were about the same (Energy Five, 2017). In 2018, the price of inverters ranged from €0.085/W to €0.25/W (Understand Solar, n.d.). Taking all this into account, the cost of the inverter was set at €100/kW, which was also equal to €0.1/W, with the same amount for construction and site development, construction works, foundations and assembly as well as for electrical equipment. Unforeseen costs were similarly to those specified by Benković (2021) as 5% of the investment costs.

Table 4
Investment costs for SPPs in FBiH

Component	Price (€/kW)
Solar panels	€300/kW
Inverters	€100/kW
Construction	€100/kW
Site development, construction works, foundations, assembly	€100/kW
Electrical equipment	€100/kW
Grid connection	€1,000
Documentation	€4,500
Unforeseen costs	5% of total investment costs
Total investment costs	∑ Depending on the size of solar power plant (kW)

Source: Authors' calculation, 2021.

If the investor decides to purchase the land, then additional investment costs were applied, obtained through the market analysis.

Table 5
Estimated land cost for solar power plants in FBiH

	Land size	Land price
Micro SPP	100 m^2	€5,000
Mini SPP	700 m_2	€20,000
Small SPP	4000 m^2	€50,000

Source: Authors' calculation, 2021.

The operating costs included inverter replacement after a certain number of years, set at 12 years based on previous research and the market data. They also included land lease in case the investor did not opt to buy land and did not have his own land suitable for investment. The land lease was formed using the market data. Given the increase in rental prices is a common phenomenon, an increase in lease costs of 1.50% was assumed.

Table 6
Estimated costs of land lease for SPPs in FBiH

	Land size	Annual lease
Micro SPP	100 m^2	€1,500
Mini SPP	700 m_2	€3,500
Small SPP	4000 m^2	€8,000

Source: Authors' calculation, 2021.

The operating costs also included maintenance and insurance costs, which were estimated as follows after the market analysis.

Table 7
Estimated costs of maintenance and insurance for SPPs in FBiH

Maintenance costs	% of investment	0.35%
Annual growth of maintenance costs	% /year	1.50%
Insurance costs	% of investment	0.50%

Source: Authors' calculation, 2021.

Results of the Empirical Research and Discussion

Using the previously described inputs, the financial analysis was conducted for: (1) all possible financing combinations, (2) investor's decisions on land lease/purchase/ownership, as well as (3) the solar power plant being in the incentive system or not, as well as (4) the size of the solar power plant. This means that the financial analysis was carried out for 162 different scenarios. Based on the obtained NPV, IRR, PP and BCR, an insight into the operation of solar power plants in FBiH was obtained with previously defined assumptions. First, the results for micro solar power plants in Bjelašnica, Bihać-Željava and Livanjsko polje are presented, followed by the results for mini solar power plants and small solar power plants per locations.

Mikro SPP 15 kW- The selected locations for the mikro SPP case study are Bjelašnica, Bihać - Željava and Livanjsko polje. Below are the results of the conducted analysis.

I) Bjelašnica: Capacity 0.015 MW – Annual production of electricity 19.56 MWh

Table 8
Output of the study for the micro SPP on the location Bjelašnica

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I[1]	WITHOUT I[2]	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 100 m^2 €1,500 per year	IRR	-	-	-	-	-	-
	NPV	-	-	-	-	-	-
	PP	-	-	-	-	-	-
	BCR	-	-	-	-	-	-
Own land	IRR		-	19.36 %	-	12.31 %	-
	NPV	€7,803	-	€5,040	-	€2,276	-
	PP	0 years	-	7 years	-	11 years	-
	BCR		-	1.60	-	1.14	-
Land purchase 100 m^2 €5,000	IRR		-	10.84 %	-	-	-
	NPV	€4,204	-	€577	-	-	-
	PP	0 years	-	19 years	-	-	-
	BCR		-	1.05	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The micro SPP on the location of Bjelašnica with the capacity of 15 kW is extremely profitable with incentives, with both the own and purchased land, regardless of the financing method. The IRR ranges from 10.84 to 19.36%, and the PP from 0 to 19 years.

II) Bihać – Željava: Capacity 0.015 MW – Annual production of electricity 17.32 MWh

[1] WITH INCENTIVES (WITH I)
[2] WITHOUT INCENTIVES (WITHOUT I)

Table 9
Output of the study for the micro SPP on the location Bihać-Željava

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 100 m^2 €1,500 per year	IRR	-	-	-	-	-	-
	NPV	-	-	-	-	-	-
	PP	-	-	-	-	-	-
	BCR	-	-	-	-	-	-
Own land	IRR		-	15.26 %	-	10.02 %	-
	NPV	€5,547	-	€2,783	-	€20	-
	PP	0 years	-	9 years	-	25 years	-
	BCR		-	1.33	-	1	-
Land purchase 100 m^2 €5,000	IRR		-	-	-	-	-
	NPV	€1,879	-	-	-	-	-
	PP	0 years	-	-	-	-	-
	BCR		-	-	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The micro solar power plant on the location of Bihać-Željava with the capacity of 15 kW is also extremely profitable with incentives, with both the own and purchased land, regardless of the financing method. The IRR ranges from 10.02 to 15.26%, and the PP from 0 to 25 years.

III) Livanjsko Polje: Capacity 0.015 MW – Annual production of electricity 19.78 MWh

Table 10
Output of the study for the micro SPP on the location Livanjsko polje

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 100 m^2 €1,500 per year	IRR	-	-	-	-	-	-
	NPV	-	-	-	-	-	-
	PP	-	-	-	-	-	-
	BCR	-	-	-	-	-	-
Own land	IRR		-	19.76 %	-	12.53 %	-
	NPV	€8,025	-	€5,261	-	€2,498	-
	PP	0 years	-	7 years	-	11 years	-
	BCR		-	1.63	-	1.15	-
Land purchase 100 m^2 €5,000	IRR		-	11.16 %	-	-	-
	NPV	€4,426	-	€798	-	-	-
	PP	0 years	-	17 years	-	-	-
	BCR		-	1.07	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The micro SPP on the location of Livanjsko polje with the capacity of 15 kW is also extremely profitable with incentives, with both the own and purchased land, regardless of the financing method. The IRR ranges from 11.16 to 19.76%, and the PP from 0 to 17 years. Therefore, micro SPPs in FBiH are extremely profitable investments with incentives, regardless of the financing method. The only segment that points to unprofitability is identified with the land lease option, while both the purchased and own land are inputs that contribute to generating profitability. Land possession in the selected locations and a 50:50 financing ratio of own and borrowed sources allows investors in micro solar power plants to generate 15.26% < IRR <19.76%, €2,783 < NPV < €5,040, with the PP from seven to nine years, and the total investment costs of approximately €16,800. Furthermore, the purchase of land in selected locations (except for Bihać-Željava) and a 50:50 financing ratio of own and borrowed sources enables investors in micro solar power plants to generate 10.84% < IRR < 11.16%, €577 < NPV < €798 with the PP of 17 to 19 years and investment costs of approximately €22,050.

Mini SPP 100 Kw- The selected locations for the mini SPP case study are, just as for the micro SPPs, Bjelašnica, Bihać – Željava and Livanjsko polje. Below are the results of the conducted analysis.

I) Bjelašnica: Capacity 0.1 MW – Annual production of electricity 130.42 MWh

Table 11

Output of the study for the mini SPP on the location Bjelašnica

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 700 m2 €3,500 per year	IRR	-	-	11.09 %	-	-	-
	NPV	-	-	€2,254	-	-	-
	PP	-	-	15 years	-	-	-
	BCR	-	-	1.06	-	-	-
Own land	IRR		11.54 %	22.59 %	-	14.30 %	-
	NPV	€47,391	€1,766	€34,350	-	€21,309	-
	VR	0 years	22 years	6 years	-	10 years	-
	BCR		-	1.87	-	1.27	-
Land purchase 700 m^2 €20,000	IRR		-	14.85 %	-	10.00 %	-
	NPV	€32,994	-	€16,498	-	€3	-
	PP	0 years	-	10 years	-	25 years	-
	BCR		-	1.33	-	1	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The mini SPP on the location of Bjelašnica with the capacity of 100 kW is an extremely profitable investment with incentives, regardless of the financing method and regardless of the land status (purchased, leased or previously owned by the investor). The IRR ranges from 10.00 to 22.59%, and the PP from 0 to 25 years. In addition, this mini solar power plant is profitable even without the incentives provided that it is fully credit financed and that it is constructed on the land already owned by the investor.

II) Bihać – Željava: Capacity 0.1 MW – Annual production of electricity 115.48 MWh

Table 12
Output of the study for the mini SPP on the location Bihać-Željava

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 700 m2 €3,500 per year	IRR		-	-	-	-	-
	NPV	€3,170	-	-	-	-	-
	PP	0 years	-	-	-	-	-
	BCR		-	-	-	-	-
Own land	IRR		-	18.31 %	-	11.93 %	-
	NPV	€35,444	-	€22,403	-	€9,362	-
	PP	0 years	-	8 years	-	14 years	-
	BCR		-	1.57	-	1.12	-
Land purchase 700 m^2 €20,000	IRR		-	11.35 %	-	-	-
	NPV	€21,045	-	€4,552	-	-	-
	PP	0 years	-	18 years	-	-	-
	BCR		-	1.09	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The mini SPP on the location of Bihać-Željava with the capacity of 100 kW is also extremely profitable with incentives, regardless of the financing method and regardless of the land status (leased, purchased or previously owned by the investor). The IRR ranges from 11.35 to 18.31%, and the PP ranges from 0 to 18 years.

III) Livanjsko polje: Capacity 0.1 MW – Annual production of electricity 131.87 MWh
Table 13
Output of the study for the mini SPP on the location Livanjsko polje

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 700 m2 €3,500 per year	IRR		-	13.45 %	-	-	-
	NPV	€16,454	-	€9,096	-	-	-
	PP	0 years	-	24 years	-	-	-
	BCR		-	1.23	-	-	-
Own land	IRR		12.21 %	23.00 %	-	14.52 %	-
	NPV	€48,550	2,458 €	€35,569	-	€22,468	-
	PP	0 years	21 years	6 years	-	10 years	-
	BCR		-	1.90	-	1.28	-
Land purchase 1,700 m^2 €20,000	IRR		-	15.19 %	-	10.19 %	-
	NPV	€34,153	-	€17,658	-	€1,162	-
	PP	0 years	-	10 years	-	23 years	-
	BCR		-	1.35	-	1.01	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The mini SPP on the location of Livanjsko polje with the capacity of 100 kW is also an extremely profitable investment with incentives, on the previously owned, purchased, or leased land, regardless of the financing method. Also, it is profitable without incentives when fully credit financed and constructed on the land already owned by the investor. The IRR ranges from 10.19 to 23.00%, and the PP is from 0 to 23 years.

Hence, mini SPPs in FBiH are also extremely profitable investments, regardless of the financing method. Unlike micro solar power plants, mini solar power plants show profitability for all combinations when it comes to land (lease, purchase, previously owned) with different output combinations. Also, mini solar power plants show profitability even without incentives for the locations Bjelašnica and Livanjsko polje with different output combinations.

Land possession in the selected locations and a 50:50 financing ratio of own and borrowed sources allows investors in mini solar power plants to generate 18.31% < IRR < 23.00%, €22,403 < NPV < €35,569 with incentives, with the PP of six to nine years, and with the total investment costs of €79,275. Furthermore, land purchase in the selected locations allows investors in mini solar power plants to generate 11.35% < IRR < 15.19%, €4,552 < NPV < €17,658 with incentives and a 50:50 financing ratio of own and borrowed sources, with the PP from 10 to 18 years and investment costs of approximately €100,275.

Land lease in the selected locations (except for Bihać-Željava) allows investors in mini solar power plants to generate 11.09% < IRR < 13.45%, €2,254 < NPV < €9,096 with incentives and a 50:50 financing ratio of own and borrowed sources, with the PP of 15 to 24 years and investment costs of €79,275. Finally, investors in mini solar power plants on the locations of Bjelašnica and Livanjsko polje are able to generate 11.54% < IRR < 12.21%, €1,766 < NPV < €2,458, in the period of approximately 20 years, without incentives, provided that they possess their own land and have a 50:50 financing ratio of own and borrowed sources (Bjelašnica) or 100% equity capital (Livanjsko polje), with the investment costs of approximately €79,275.

Small SPP 500 Kw- The selected locations for the small SPP case study are, just as for the micro and mini SPPs, Bjelašnica, Bihać - Željava and Livanjsko polje. Below are the results of the conducted analysis.

I) Bjelašnica: Capacity 0.5 MW – Annual production of electricity 652.08 MWh

Table 1
Output of the study for the small SPP on the location Bjelašnica

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 4,000 m^2 €8,000 per year	IRR		-	12.00 %	-	-	-
	NPV	€86,233	-	€24,829	-	-	-
	PP	0 years	-	16 years	-	-	-
	BCR		-	1.13	-	-	-
Own land	IRR		15.79 %	17.19 %	-	11.53 %	-
	NPV	€159,596	25,686 €	€98,192	-	€36,787	-
	PP	0 years	18 years	8 years	-	16 years	-
	BCR		-	1.53	-	1.1	-
Land purchase 4,000 m^2 €50,000	IRR		-	13.45 %	-	-	-
	NPV	€123,604	-	€53,563	-	-	-
	PP	0 years	-	14 years	-	-	-
	BCR		-	1.25	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The small SPP on the location of Bjelašnica with the capacity of 500 kW is a profitable investment with incentives, regardless of the financing method and regardless of the land status (purchased, leased or previously owned by the investor). The IRR ranges from 12.00 to 17.19%, and the PP from 0 to 16 years. In addition, this small solar power plant is profitable even without the incentives provided that it is fully credit financed and that it is constructed on the land already owned by the investor.

II) Bihać – Željava: Capacity 0.5 MW – Annual production of electricity 577.39 MWh

Table 15
Output of the study for the small SPP on the location Bihać-Željava

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 4,000 m^2 €8,000 per year	IRR		-	-	-	-	-
	NPV	€36,106	-	-	-	-	-
	PP	0 years	-	-	-	-	-
	BCR		-	-	-	-	-
Own land	IRR		-	13.63 %	-	-	-
	NPV	€110,544	-	€49,140	-	-	-
	PP	0 years	-	13 years	-	-	-
	BCR		-	1.26	-	-	-
Land purchase	IRR		-	10.29 %	-	-	-
	NPV	€73,907	-	€4,511	-	-	-

4,000 m^2 €50,000	PP	0 years	-	24 years	-	-	-
	BCR		-	1.02	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The small SPP on the location of Bihać-Željava with the capacity of 500 kW is also profitable with incentives, regardless of the financing method and regardless of the land status (leased, purchased or previously owned by the investor). The IRR ranges from 10.29 to 13.63%, and the PP ranges from 0 to 24 years

III) Livanjsko Polje: Capacity 0.5 MW – Annual production of electricity 659.33 MWh

Table 16
Output of the study for the small solar power plant on the location Livanjsko polje

Financing:		100% credit		50% credit, 50% equity capital		100% equity capital	
CONDITIONS		WITH I	WITHOUT I	WITH I	WITHOUT I	WITH I	WITHOUT I
Lease 4,000 m^2 €8,000 per year	IRR		-	12.37 %	-	-	-
	NPV	€90,995	-	€29,591	-	-	-
	PP	0 years	-	15 years	-	-	-
	BCR		-	1.16	-	-	-
Own land	IRR		16,90 %	17.54 %	-	11.72 %	-
	NPV	€164,357	29.130 €	€102,953	-	€41,549	-
	PP	0 years	18 god.	8 years	-	16 years	-
	BCR		-	1.55	-	1.11	-
Land purchase 1,700 m^2 €20,000	IRR		-	13.76 %	-	-	-
	NPV	€128,365	-	€58,324	-	-	-
	PP	0 years	-	13 years	-	-	-
	BCR		-	1.27	-	-	-

Source: Authors' calculation using the Global Solar Atlas, 2022.

The small SPP on the location of Livanjsko polje with the capacity of 500 kW is also an extremely profitable investment with incentives, on the previously owned, purchased, or leased land, regardless of the financing method. Also, it is profitable without incentives when fully credit financed and constructed on the land already owned by the investor. The IRR ranges from 11.72 to 17.54%, and the PP is from 0 to 18 years.

Hence, small SPPs in FBiH are also extremely profitable investments, regardless of the financing method. Unlike micro solar power plants, small solar power plants also show profitability for all combinations when it comes to land (lease, purchase, previously owned) with different output combinations. Also, small solar power plants show profitability even without incentives for the locations Bjelašnica and Livanjsko polje with different output combinations.

Land possession in the selected locations and a 50:50 financing ratio of own and borrowed sources allows investors in small solar power plants to generate 13.63% < IRR < 17.54%, €49,140 < NPV < €102,953 with incentives, with the PP of eight to 19 years, and with

the total investment costs of approximately €373,275 . Furthermore, land purchase in the selected locations allows investors in small solar power plants to generate 10.29% < IRR < 13.76%, €4,511 < NPV < €58,324 with incentives and a 50:50 financing ratio of own and borrowed sources, with the PP from 13 to 24 years and investment costs of approximately €425,775.

Land lease in the selected locations (except for Bihać-Željava) allows investors in small solar power plants to generate 12.00% < IRR < 12.37%, €24,829 < NPV < €29,591 with incentives and a 50:50 financing ratio of own and borrowed sources, with the PP of 15 to 16 years and investment costs of approximately €373,275. Finally, investors in small solar power plants on the locations of Bjelašnica and Livanjsko polje are able to generate 15.79% < IRR < 16.90%, €25,686 < NPV < €29,130, in the period of approximately 18 years, without incentives, with credit financing above 50% and the investment costs of approximately €373,275.

Conclusion

The presented results of the case study and 162 scenarios tested show the expected return rates, the NPV, the BCR as well as the PP for investments with a cautious approach to the investment risk potentials when it comes to this type of venture in FBiH, given that the discount rate of 10% was set, which is typically, but not exclusively, higher than the discount rates used in other countries. With such an attitude towards risk and the given assumptions, the results showed that solar power plants are much more profitable in the case when the producer is in the incentive system. However, even with such a defined threshold of acceptance of economic profitability, there are scenarios that point to the possibility of profitable business without incentives.

Comparing the results of the financial analysis for micro, mini, and small solar power plants, it can be observed that profitability is higher with larger investments. Also, if the locations are compared, the locations Bjelašnica and Livanjsko polje bring better outputs to investors in solar power plants, when compared to the location Bihać-Željava. With the assumed inputs, given with a high level of caution, as explained in the introduction, only investments in micro solar power plants do not show profitability without incentives, while investments in mini as well as small solar power plants prove to be profitable even without incentives.

Given that the case studies showed the possibility of profitable business operations of solar power plants in FBiH without incentives with a cautious approach to investment risk potentials and the given assumptions, the conclusion is imposed that lower discount rates, i.e., the lower threshold of acceptance of economic profitability, would create a significantly higher number of scenarios that point to profitable business outside the incentive system. In addition, different financing structures are certainly one of the influencing factors, which is the result of investors' individual approaches. The tested scenarios used the assumptions of 100% own sourced, 100% borrowed sources, and a 50:50 financing ratio of own and borrowed sources. Given the abovementioned, we cannot reject the main research hypothesis which reads, "There is return on investment in solar energy projects on the market of FBiH". This means that the analyzed scenarios show that investments in solar energy projects in the market of FBiH are financially profitable. Understandably, the profitability level is different, depending on the selected financing assumptions and the analyzed scenario.

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