ENHANCING BANKABILITY IN RENEWABLE ENERGY PROJECTS THROUGH EFFECTIVE RISK MANAGEMENT

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Abstract: *To determine the outcome of risk management on the bankability, p*olitical /regulatory risk including environmental risk, technology risk and financial risk *on the bankability of green energy investments*, using survey responses to measure their perceived importance. *A survey was conducted in Serbia, in 2024 involving 242 Serbian companies. The research was carried out in collaboration with the Serbian Association of Employers. Twelve factors were identified, three for each variable. Business owners and managers, as the primary respondents, evaluated predefined statements using a Likert scale.* Correlation analysis is employed to examine the strength and direction of the relationships between selected variables, helping to identify whether, and to what extent, changes in risk *that* the bankability of renewable energy projects is significantly influenced by the selected risk factors—namely regulatory, financial, and technological risks. This study factors are associated with variations in the bankability of renewable energy projects. *The results revealed* provides a meaningful contribution to the existing literature on renewable energy by offering empirical insights into the factors influencing project bankability, with a specific focus on the Balkan region and Serbia. It addresses a regional gap by highlighting how risk management practices impact investment viability in the context of emerging renewable energy markets.

Keywords: *Renewable Energy Investments, Risk Management, Project Bankability, Serbia*

1. INTRODUCTION

Renewable energy is one of the key solutions to deliver low carbon and secure supplies of energy. Years of research and development have brought a number of renewable energy technologies to a stage where they are technologically mature and ready for a more widespread market introduction. However, there is still a gap between renewable energy promoters and financing organizations (Vuković et al., 2023). Traditionally investment in energy infrastructure has always involved risk; however, with the shift toward decarburization, decentralization, and digitalization, risk management has has evolved into a key component of renewable energy strategies. During the early milestones in green energy project development from 1990s and early 2000s, projects were heavily reliant on government subsidies, which masked some of the underlying investment risks. As support mechanisms evolved and

markets matured, the emphasis shifted to ensuring project bankability through risk-aware financing structures and private sector engagement (Jevtić et al.,2013). Risk management in energy investments has evolved alongside the energy transition movement (Figure 1), gaining prominence after the international climate accords of Kyoto (1997) and Paris (2015)(Radović et al., 2013; Miškić et al., 2017). These global accords emphasized the need for clean energy solutions, catalyzing significant investments in renewable technologies. To meet EU binding target of at least 20% green emery in final consumption by 2020, considerable investments are required, €60-70 billion per yearend (De Jager, 2011), total annual investments are estimated. These investments will have to come from investors, bankers and equity providers. In contrast to investments in conventional electricity generation, investments in renewable energy sources (RES), such as wind and solar power, require large upfront investments, but low working/operating capital. Most investments are to be made upfront, before the system becomes operational. From an investor's perspective, this means that the overall investment risks increases. To compensate for this risk, investors require a higher rate of return on their investments, leading to increased cost of capital for RES investments. Before investing in a renewable energy project, investors indeed perform a risk analysis to decide whether to invest or not. If investors perceive an investment as risky, they will demand a higher fee for making capital available. The cost of this compensation – the cost of capital - must be paid from the revenues of the projects and, thus, directly influences the cost structure of the project.
In that purpose, a field survey was provided in Serbia in 2024, on the sample of 242 Serbian companies to answer the RQ: "What is the influence of regulatory, financial, and technological risks on the bankability of renewable energy investments?" The structure of this paper includes an introduction and a review of relevant literature, followed by the research methodology and results. The conclusion and references are provided in the final sections.

2. LITERATURE REVIEW

Early literature, such as that by Hoffert et al. (2002) and International Energy Agency (2024), underscored the technical, regulatory, and financial risks that distinguish renewables from conventional energy sources. Over time, researchers like Lessard, & Miller (2012) and Painuly (2001), identifying barriers to renewable energy penetration, emphasizing financial and institutional risks have emphasized the role of policy stability, technology maturity, and financial incentives in reducing perceived project risk, Beck & Martinot (2024) discussed public finance mechanisms and risk mitigation in clean energy development, Lessard &Miller (2001) proposed frameworks for risk allocation in large-scale infrastructure projects, Lütken & Michaelowa (2008) examined risk sharing for climate-related investments through carbon finance, UNEP regularly publish reports highlighting the importance of mitigating risk to scale up investment in clean energy. Studies by Dominković et al.(2016), Stojiljković & Radivojević et al.(2020); Josimović & Dedjanski, 2024; Dedjanski et al., 2010), and the Energy Community Secretariat highlight gaps in risk-sharing frameworks in the Balkans. They emphasize the need for: greater transparency in licensing processes, risk-sharing public-private partnerships (PPPs), and stable incentive schemes aligned with EU energy policy. For Serbia and the broader region, implementing comprehensive risk management frameworks ensures: enhanced bankability of projects (attracting lenders and equity investors), better alignment with EU energy goals, and increased social acceptance and environmental sustainability.

3. METHODOLOGY

In Serbia, field research was conducted in 2024 with a sample of 243 enterprises. The research logistics were supported by the Serbian Association of Employers. The online questionnaire focused on the potential impact of three defined independent variables—financial, technology and policy/regulatory risks—on *the bankability of renewable energy investments, considered the dependent variable. Twelve factors were identified, three for each variable. Business owners and managers, as the primary respondents, evaluated predefined statements using a Likert scale.* The hypothesis H_0 posits that the independent variables—financial (A), technology (B), and policy/regulatory risk (C) either do not have a direct influence on the dependent variable (B*ankability of renewable energy investments* (D), or do have an influence, H_1. For each independent variable, three statements were defined.

A: Financial risk- Enterprise and Stakeholders-Level Statements

The reason financial risk is chosen as Independent Variable A in this research lies in its critical influence on the financial viability of renewable energy projects. Financial risk refers to the potential for monetary loss or underperformance due to factors such as limited capital availability, cost overruns, market fluctuations, and uncertain returns on investment. In the context of renewable energy, this risk is amplified by high upfront costs, reliance on policy incentives, and evolving market dynamics—all of which can significantly impact a project's bankability and its ability to attract external financing.

- *a1. High initial capital requirements reduce the attractiveness of renewable energy projects to investors.*
- *a2. Financial institutions show greater willingness to fund renewable energy projects that demonstrate strong management of technology, policy, and market risks*
- *a3. Inaccurate financial forecasting contributes to underperformance and low investor trust.*

B. Technology- Enterprise -Level Statements

This type of risk arises from the potential for technological underperformance, obsolescence, or failure—factors that may impede project implementation, increase operational and maintenance costs, or reduce expected energy output. In the context of green power, where many technologies are still evolving or rapidly advancing, technology risk can significantly affect project success, influencing timelines, investment returns, and long-term sustainability.

- *b1. Renewable energy projects that use proven and commercially mature technologies are perceived as more bankable due to reduced technological uncertainties.*
- *b2. The risk that the technology may require more maintenance than initially anticipated or those failures in technology performance could disrupt energy generation and decrease revenue streams.*
- *b3. Rapid technological obsolescence in some renewable technologies creates uncertainty for long-term investment returns.*

C. Policy/Regulatry risk- National /Institutional- Level Statements:

Thus risk refers to the uncertainty and potential negative impact on renewable energy projects arising from changes or inconsistencies in government policies, regulations, and legal frameworks. Common sources of regulatory risk include changes in taxation laws, feed-in tariffs, licensing procedures, environmental regulations, and lack of clarity or enforcement in legal frameworks. A transparent regulatory framework and a stable policy environment increase the financial attractiveness and bankability of renewable energy investments.

- *c.1 Strong and consistent government commitment to renewable energy policies increases the likelihood of project financing and success*
- *c2. The absence of a stable legal framework for power purchase agreements (PPAs),* environmental and energy regulations *jeopardizes project bankability.*

- *c3. Delays in obtaining necessary permits and approvals negatively affect the timeline and bankability of projects.*

D. Bankability of renewable energy investments- Enterprise/Stakeholders- Level Statements

Bankability which measures how likely a renewable energy project is to secure the necessary funding and successfully reach commercial operation, minimizing risks to lenders and investors, is considered dependent variable in the research (D), with further claims:

- *d1. Robust risk identification and mitigation strategies significantly enhance the bankability of renewable energy investment projects.*
- *d2. A thorough risk assessment, including sensitivity analyses and stress testing, strengthens the project's ability to secure financing.*
- *d3. Stakeholder engagement and community acceptance contribute to lowering social and political risks, thereby improving overall project bankability.*

3.1 Results

In Table 2. Are presented results of values for claims (ABCD).

Claim	Central Tendency		Spread	Spread Measure	Lopsidedness		Tail Weight	
	Data Point	Error Margin	Data Point	Error Margin	Data Point	Error Margin	Data Point	Error Margin
A Financial risk								
a1. High initial capital requirements reduce the attractiveness of renewable energy projects to investors.	4,42	0,042	0,660	0,436	-0,711	0,156	-0,553	0,312
a2. Financial institutions show greater willingness to fund renewable energy projects that demonstrate strong management of technology, policy, and market risks.	4,38	0,040	0,627	0,393	-0,488	0,156	-0,643	0,312
a3. Inaccurate financial forecasting contributes to underperformance and low investor trust.	4,35	0,036	0,558	0,312	-0,401	0,156	1,036	0,312
B. Technology risk								
b1. Renewable energy projects that use proven and commercially mature technologies are perceived as more bankable due to reduced technological uncertainties.	4,33	0,047	0,727	0,528	-0,851	0,156	0,302	0,312
b2. The risk that the technology may require more maintenance than initially anticipated or those failures in technology performance could disrupt energy generation and decrease revenue streams.	3,86	0,037	0,571	0,326	-0,006	0,156	-0,070	0,312
b3. Rapid technological obsolescence in some renewable technologies creates uncertainty for long-term investment returns.	4,31	0,040	0,625	0,391	-0,346	0,156	-0,659	0,312
C. Polic/regulatory risk								
c1. Strong and consistent government commitment to renewable energy policies increases the likelihood of project financing and success	4,48	0,036	0,563	0,317	-0,497	0,156	-0,771	0,312
c2. The absence of a stable legal framework for power purchase agreements (PPAs), environmental and energy regulations jeopardizes project bankability.	4,11	0,038	0,595	0,354	-0,274	0,156	0,773	0,312
c3. Delays in obtaining necessary permits and approvals negatively affect the timeline and bankability of projects.	4,40	0,043	0,669	0,448	-0,831	0,156	0,284	0,312
D. B*ankability of renewable energy investments*								
d1. Robust risk identification and mitigation strategies significantly enhance the bankability of renewable energy investment projects.	3,95	0,034	0,525	0,276	-0,748	0,156	3,078	0,312
d2. A thorough risk assessment, including sensitivity analyses and stress testing, strengthens the project's ability to secure financing	4,16	0,036	0,554	0,307	0,054	0,156	0,006	0,312

d3. Stakeholder engagement and community acceptance contribute to lowering social and political risks, thereby improving overall project bankability.	4,36	0,036	0,562	0,315	-0,438	0,156	1,002	0,312

Table 1: Values for claims (ABC&D)
(Source: Authors)

Considering the statistical values provided in Table 1, the following conclusions can be inferred: Average Scores indicate that the general ratings range from 3.86 to 4.48. The highest mean value was recorded for variant c1 (4.48), while the lowest was for b2 (3.86). This suggests that most variants have relatively high average ratings, with some, like b2, receiving lower evaluations. Measure of Dispersion ranges from 0.036 (for a3, c1, d2, d3) to 0.047 (for b1). These values suggest that most data points are closely grouped around the mean, with slight variations. The variances follow a similar pattern, typically remaining low, indicating limited data spread. Skewness indicates that the data is generally slightly negatively skewed, with most values clustering towards the higher end of the scale. For instance, variants a1 (-0.711) and b1 (-0.851) exhibit significant negative skewness, suggesting that scores are mainly concentrated at the upper values, while b2 (-0.006) and d2 (0.054) show minimal or nearly neutral skewness.Distribution Shape indicates that most variants have relatively flat distributions, meaning the data is spread out rather than concentrated in the middle. Variants like a3 (1.036) and d1 (3.078) show higher values, suggesting more outliers or peaks. In contrast, variants like b2 and d2 exhibit slight negative kurtosis, indicating a wider distribution.The data show that most variants have high average values with little variation. Skewness and kurtosis suggest that the data are slightly asymmetrical, with some variants deviating from a normal distribution, potentially reflecting sensitivity to specific factors. Overall, the dataset offers valuable insights into variant behavior, focusing on central tendencies, dispersion, and distribution shape, which can inform further analysis.

Predictive Model's Performance Evaluation. Considering the statistical values provided in Table 1, the following conclusions can be inferred: Correlation Strength (R) is 0.850, indicating a strong positive relationship between the independent and dependent variables. This suggests that the model has good predictive power and a significant association between the predictors and the outcome.The adjusted fit index is 0.720, nearly identical to the R-squared. It indicates that the model remains effective after considering the number of predictors, providing a more reliable measure of model quality, especially when comparing models with varying predictors.The forecast error is 0.22692, representing the average deviation in predicting the dependent variable. A smaller value signifies greater accuracy, indicating that the model provides relatively precise predictions. The model demonstrates strong explanatory power, with an R value of 0.850, indicating a robust correlation between the predictor and target variable. The explained variance of 72.3% shows the model explains most of variance, while the Tucker-Lewis Index confirms its effectiveness even with multiple predictors. The forecast error of 0.22692 indicates accurate predictions, though there is potential for further improvement.

Model	R	Explained Variance	Corrected R Square	Residual Standard Error
	0,850	0,723	0,720	0,22692

Table 2. Model Summary
Source (Authors)

As shown in Table 3 the ANOVA lead to the following conclusions: Regression Sum of Squares is 32,006, representing the variation explained by the model and how well the predictors account for the dependent variable. Residual Sum of Squares is 12,255, representing the unexplained variation not accounted for by the model. A smaller value indicates better model fit. Total Variation is 44,261, total variance, representing the overall variation in the data. Freedom Degrees for regression is 3, corresponding to the number of predictors. The degrees for residuals is 238, and for total variation, it is 241. Average Square for regression is 10.669, calculated by dividing the regression sum of squares (32.006) based on its variance components (3). The root mean square for the residuals is 0.051, calculated by dividing the variance from the error term (12.255) by its corresponding statistical parameters (238). The F-statistic is 207.186, computed by dividing the mean square for the regression model (10.669) by the residual mean square (0.051). A high value indicates strong explanatory power and model validity. The confidence level is 0.000, under the 0.05 limit, indicating that the model is statistically significant and the relationship between variables is likely genuine. The ANOVA results confirm the model's statistical significance. A high F-ratio of 207.186 and a very strong evidence against the null hypothesis (0.000) demonstrate a meaningful association between the predictors and the outcome variable, with the model effectively explaining the data variation [$F(3,238) = 207.186$, $p < 0.0001$]. The model accounts for a substantial portion of the total variation (regression sum of squares = 32.006), while the remaining variation (residual sum of squares) is minimal and does not undermine the model's validity. Therefore, the null hypothesis (**H_0**: A, B, and C do not shape D) **Is ruled out, with the alternative hypothesis being favored** (**H_1**: A, B, and C influence D).

ANOVA					
Model	Squared deviations	**df**	Variance estimate	**F**	**Sig.**
Outcome prediction	32,006	3	10,669	207,186	0,000
Residual	12,255	238	0,051		
Total	44,261	241			

Table 3. Variance Analysis Results
Source (Authors)

T**he** predictor estimates in Table 4 support the following conclusions:

Raw coefficient estimates Capture the unique effect of each predictor on the outcome variable in their original units (Fig 1):

Beta weights (Fig. 2) show the relative impact of each predictor on the outcome using standardized values.

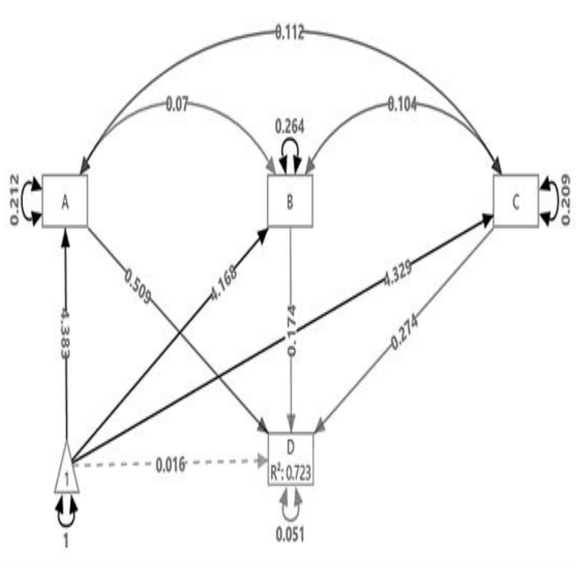

Figure 1. Raw coefficient estimate
Source (Authors)

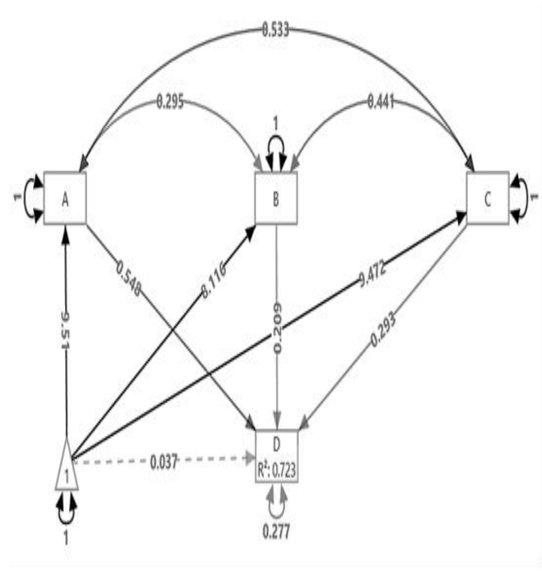

Figure 2. Beta weights
Source (Authors)

Baseline value is 0.016 (SE = 0.169), indicating the expected outcome when all predictors (A, B, C) are zero. Its closeness to zero suggests minimal deviation in the dependent variable at that point. Effect estimate for A is 0.509 (SE = 0.038), indicating that a one-unit increase in A raises the dependent variable by 0.509, holding other variables constant.Effect estimate for B is 0.174 (SE = 0.032), meaning a one-unit rise in B increases the outcome by 0.174.Effect estimate for C is 0.274 (SE = 0.040), suggesting a similar positive impact from C.	A (β = 0.548) has the strongest effect, indicating it's the most influential variable. B (β = 0.209) has a moderate impact. C (β = 0.293) also contributes significantly, though less than A. t-scores **and** significance levels indicate the statistical relevance of the **effect estimates**. All predictors—A (13.564), B (5.477), and C (6.811)—show high **t-scores with** p-values of 0.000, confirming that each has a significant impact on the dependent variable**.** Variables A, B, and C are significant predictors of the dependent variable ($p < 0.05$), with A showing the strongest effect (β = 0.548). All **regression weights** are positive, indicating that increases in A, B, or C lead to increases in the outcome. These results confirm the model's predictive validity and the meaningful contribution of all predictors.

Model	*Raw coefficient estimates*		*Beta weights*	t	Sig.
	B	Estimated stand. dev.	Beta		
(Constant)	0,016	0,169		0,093	0,926
A	0,509	0,038	0,548	13,564	0,000
B	0,174	0,032	0,209	5,477	0,000
C	0,274	0,040	0,293	6,811	0,000

Table 4. Weights
Source (Authors)

The predictive model allows for the evaluation of how changes in variables A, B, and C impact the dependent variable D. The parameter estimates from Table 4 illustrate the magnitude and positive direction of influence for each independent variable (A, B, and C) on D, providing deeper insight into their relationships. The linear predictive equation (formula 1) is:

$$\boldsymbol{D = 0.016 + 0.509 \cdot A + 0.174 \cdot B + 0.274 \cdot C} \quad (1)$$

The predictive model provides valuable insight into the data (Table 5), as the predicted values have an average of 4.1584 and a small standard deviation of 0.36442.

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3,2059	4,8011	4,1584	0,36442	242
Residual	-,99657	1,19373	0,00000	0,22550	
Std. Predicted Value	-2,614	1,764	0,000	1,000	
Std. Residual	-4,392	5,261	0,000	0,994	

Table 5. Deviation Metrics
Source (Authors)

The prediction error metrics(residual) have an average close to 0, suggesting that the model is not systematically biased.

4. CONCLUSION

The findings of this research confirm that the bankability of renewable energy projects is significantly influenced by the selected risk factors—namely regulatory, financial, and technological risks—demonstrating its role as a dependent variable in the analysis. Bankability, in this context, refers to the extent to which a project is perceived as financially viable, creditworthy, and capable of securing external financing from banks, investors, and lending institutions. The study reaffirms that a renewable energy project is considered bankable when it meets several critical criteria, including a robust technical design with proven technology, a sound financial structure supported by credible revenue sources such as long-term Power Purchase Agreements, and comprehensive risk management strategies that address key project uncertainties. Additionally, the presence of a qualified project team, compliance with legal and environmental standards, secure ownership and land use rights, and a stable, transparent regulatory environment further enhance the project's ability to attract financing. These findings underscore the importance of integrated risk assessment and mitigation in improving project bankability, particularly in the evolving and capital-intensive landscape of renewable energy development.

Future studies could compare the impact of risk factors on renewable energy project bankability across different regions in the Balkans or between Balkan and EU countries to identify common patterns and region-specific challenges; investigate how the influence of financial, regulatory, and technological risks evolves over time as policy frameworks and market maturity change would offer valuable dynamic insights.

POBOLJŠANJE BANKARIBILNOSTI PROJEKTA OBNOVLJIVE ENERGIJE KROZ EFIKASNO UPRAVLJANJE RIZIKOM

Apstrakt: Cilj je utvrditi ishod upravljanja rizicima na bankaribilnost, politički/regulatorni rizik, uključujući ekološki rizik, tehnološki rizik i finansijski rizik na bankaribilnost investicija u zelenu energiju, koristeći odgovore iz ankete za merenje njihovog percipiranog značaja. Anketa je sprovedena u Srbiji 2024. godine, u kojoj su učestvovale 242 srpske kompanije. Istraživanje je sprovedeno u saradnji sa Unijom poslodavaca Srbije. Identifikovano je dvanaest faktora, tri za svaku promenljivu. Vlasnici i menadžeri preduzeća, kao primarni ispitanici, procenili su unapred definisane izjave koristeći Likertovu skalu. Analiza korelacije je primenjena da bi se ispitala jačina i smer odnosa između odabranih promenljivih, pomažući da se utvrdi da li i u kojoj meri promene u riziku značajno utiču na bankaribilnost projekata obnovljive energije – naime regulatorni, finansijski i tehnološki rizici. Faktori ove studije su povezani sa varijacijama u bankaribilnosti projekata obnovljive energije. Otkriveni rezultati pružaju značajan doprinos postojećoj literaturi o obnovljivim izvorima energije nudeći empirijski uvid u faktore koji utiču na bankarnost projekata, sa posebnim fokusom na region Balkana i Srbiju. Bave se regionalnim jazom ističući kako prakse upravljanja rizicima utiču na održivost investicija u kontekstu tržišta obnovljivih izvora energije u razvoju.

Ključne reči: Investicije u obnovljive izvore energije, Upravljanje rizicima, Bankarnost projekata, Srbija

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