FINANCIAL IMPACT ON CAPITAL RETURN OF WIND ENERGY PRODUCTION STRATEGY

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Abstract

This paper evaluates the financial feasibility of the wind energy production project at the Kitka Substation (SS Kitka), focusing on its technical and economic aspects, return on capital investment, and broader environmental and social implications. The study's findings indicate that for the period of January to June 2022, the project generated total revenues of €3,749,466.11, while operating expenses amounted to €1,780,000. With a total investment of €48,000,000, the capital return for this period was calculated at €1,969,466.11. The analysis of wind energy production data from January to August 2022 recorded a total output of 56,562.25 MWh. Moreover, the project contributed €10,160,047 in revenue to the Kosovo government through wind-generated energy from the SS Kitka facility. Based on financial projections, the annual return on investment (ROI) for the capital invested is estimated at €3,938,932.22. Consequently, the full recovery of the initial €48 million investment is projected to be achieved within 12 years. These findings underscore the long-term financial viability of the SS Kitka wind energy project, reinforcing its role in promoting sustainable energy development and economic growth.

Keywords: Financial Impact, Energy Costs, Distribution, Wind Energy, Capital Investments, Kitka, Voltage, Berivojca

Authors' individual contribution: Conceptualization — S.R.; Methodology — S.R.; Validation — R.V. and V.R.; Investigation — S.R. and R.S.; Writing — Original Draft — S.R., R.S., and V.R.; Writing — Review & Editing— S.R., R.S., and G.V.; Supervision — S.R. and R.S.; Visualization — V.R.; Project Administration — S.R., R.V., and G.V.

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1. INTRODUCTION

This paper examines the role and strategic implementation and financial impact of wind energy production within the SS Kitka project. Renewable energy sources, particularly wind energy, represent an important opportunity for Kosovo. Despite the evident potential, these resources remain untapped, underscoring the need for effective strategies to harness them.

This study is based on the theory of return on investment (ROI) and risk analysis, integrating concepts of financial management and sustainable energy strategies. In conventional power systems, electricity generation primarily relies on traditional power plants that predominantly utilize fossil fuels. These power plants typically have high generation capacities, ranging from 150 MW to 1000 MW. Due to their substantial capital investment and operational costs, such facilities are often located at significant distances from consumption centers. Consequently, long-distance electricity transmission becomes necessary, necessitating the development of appropriate high-voltage and extra-high-voltage switchgear and transmission infrastructure to ensure efficient power delivery.

As alternative methods used in the research, they are Comparative methods, where through this method we managed to identify the changes in the results.

The simulation method was employed in this study, enabling us to derive accurate information regarding the causes and outcomes of the research. An in-depth analysis of risk factors, including variations in electricity prices and maintenance costs, is necessary to accurately assess the project's financial sustainability in the long run (Wüstenhagen & Menichetti, 2012).

The documentation analysis method, where through this method we managed to collect sufficient documentation on the extraction of the results we needed for research. The evolution of modern power systems is increasingly driven by the integration of distributed generation (DG) as an alternative to conventional coal-based power plants. DG units primarily utilize renewable energy sources, such as wind and solar power, for electricity generation. These generators are typically positioned near consumption centres, with their output characterized by inherent variability and non-dispatchability. Their generation capacities range from a few kilowatts to several megawatts, and they are directly connected to the distribution network. The incorporation of DG transforms the traditionally passive distribution network into an active system, significantly altering power flow dynamics. The motive of the SS Kitka project study is related to the focus and definition of several research questions:

RQ1: How does the financial structure affect the return on capital?

RQ2: How does the investment affect the environmental and social aspects?

RQ3: What are the challenges and financial benefits for investors in this sector?

RQ4: What is the level of energy production, and the impact on the project savings?

Based on the operating results of SS Kitka, we have done the cost analysis, taking into account the basis of the years of success, the capacity factor, the investment return period of the expenditure levels, and all these, that can affect the economic factors, but also in other profiles that are involved in increasing employment, protecting the environment.

The estimation of potential wind energy necessitates a comprehensive analysis of wind speed data obtained from a meteorological station located at the same geographical coordinates, in order to achieve optimal estimation accuracy. The project caught wind through SS Kitka, we are focused on the impact of the energy project on the environmental, social, and financial aspects, the production of energy-saving machines, environmental protection, and the return on equity (ROE) investments.

The SS Kitka project is a self-powered plant located in the Kitka mountains, Kosovo. SS Kitka is the first plant in Kosovo that has nine General Electric turbines, with a capacity of 32 MW, central heating of 110 m and a blade diameter of 137 m. The SS Kitka wind power plant started operating on October 11, 2018, when it was opened for commercial operation. The forecast is to produce nearly 96 million kWh for a year.

Wind energy, as an alternative source of electricity, presents not only environmental benefits but also significant financial implications, particularly concerning capital returns. This study aims to analyze the financial impact of wind energy production strategies on capital return, assessing both initial investment costs and long-term profitability (Şener et al., 2023).

As a result, there is increased interest in investments in the field of alternative sources, such as the production of wind energy and hydropower plants.

The integration of wind power plants into the distribution network has a multidimensional impact, encompassing technical, economic, techno-economic, techno-ecological, and economic-ecological perspectives. Renewable energy sources play a pivotal role in the electric power system, influencing the supply of clean energy to consumers and contributing positively to environmental sustainability.

This study aims to analyze the financial impact of wind energy production strategies on return on capital, combining theoretical and empirical analysis. The main objective of the study is a review of the literature focused on an uncertain situation of investments in wind energy and incentive rates for investments made and their subsidies.

By examining various wind energy projects, this research will explore how capital investments in wind energy can yield returns, considering factors such as technology advancements, government policies, and market demand for renewable energy (Snyder & Kaiser, 2009).

Another important aspect of renewable energy sources is their performance characteristics. These sources significantly influence the operation of power systems, particularly in terms of unexpected fluctuations in production capacity. Such variations can affect key parameters, including voltage characteristics and system frequency, thereby impacting the overall stability and performance of the grid.

The rest of the paper is structured as follows. Section 2 provides a review of the relevant literature. Section 3 presents an analysis of the methodology applied to the variables using the linear regression model. Section 4 interprets the results through the basic equations and examines their impact on capital return investments. Section 5 discusses the implications of the results. Section 6 concludes the paper.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The overall economic viability of a wind energy project can be significantly influenced by financial incentives, which are crucial for the successful implementation of wind energy systems, impacting distribution and services. Similar to other energy projects, wind energy initiatives benefit from various financial, state, local, and utility incentives.

The Database of State Incentives for Renewables and Efficiency (DSIRE) serves as a comprehensive resource, offering detailed information on incentives that support renewable energy and energy efficiency. Interested stakeholders can search by zip code to access information about available programs in their region. Additionally, as a stochastic variable, wind speed plays a critical role in characterizing the production of wind energy.

Wind energy, together with other sustainable energy sources, is among the fastest-growing technologies, exhibiting significant annual growth in installed capacity. The Global Wind Energy Council (GWEC)[1] report indicates that the global electricity generation capacity from wind energy systems reached 793 GW in 2021, representing an increase of 93 GW compared to 2020.

The financial performance and risk assessment of renewable energy investments, with a specific focus on wind power generation, offering valuable insights into the financial returns and risks associated with such projects provide a comprehensive review of financial viability and risk management strategies for wind power projects, which could help to evaluate the capital return dynamics within wind energy investments (Gatzert & Kosub, 2016).

The findings of previous studies indicate that the Weibull probability density function (PDF) demonstrates an acceptable level of accuracy, making it a suitable model for characterizing wind variations within a specific wind regime (Sadullayev et al., 2019; Tizgui et al., 2019). Consequently, analysing the statistical characteristics of wind speed is essential for accurately estimating energy production. Owing to its ease of implementation and high accuracy (Celik, 2003), the Weibull PDF is widely utilized for the statistical distribution and analysis of wind speed data.

Research on ROI in wind energy projects has shown a significant variation in return rates, influenced by factors such as subsidy policy, technology cost, and climate conditions (Gatzert & Kosub, 2016). The study on the SS Kitka Wind Farm confirms these findings, stressing that the return of the investment for the first period of operation has reached promising figures. However, critics argue that the period of capital recovery of 12 years may be sensitive to energy market changes and regulations (Borenstein, 2012).

The federal government applies subsidies and incentives to stimulate deployment for all energy technologies. The advantage of wind energy is that the energy sources are available at the lowest price where the production of this energy creates jobs. According to the Wind Vision Report, the US wind sector employs more than 100,000 workers, and wind turbine technician is one of the fastest-growing US jobs, the wind has the potential to support more than 600,000 jobs in manufacturing, installation, maintenance and support services until 2050. The wind energy compared to power plants is less pollutive as it relies on burning fossil fuels, such as coal or natural gas, which release particulate matter, nitrogen oxides and sulphur dioxide, causing human health problems and economic damage. The wind turbines do not generate atmospheric emissions that trigger acid rain, smog or greenhouse gases. Wind energy presents a sustainable and environmentally friendly alternative while contributing to national energy security, particularly in the context of declining global fossil fuel reserves, which pose a significant challenge to the long-term stability of the global economy). When planning for every energy development project a vital element is the assessment and project cost benefit, intertwined with the economic impacts of wind energy development, including the aptitude of wind energy to offset energy costs, government subsidies for energy, and other project financing incentives, policy effects on the economy of the project, analysis tools to help stakeholders estimate projects and community economic impacts. In this regard, the far biggest beneficiaries are developing countries. They have the largest ratio of solar and wind potential towards energy demand and may unlock huge domestic benefits.

2.1. Hypotheses development

Based on the literature review, this section presents the study's hypotheses. Specifically, the research examines three hypotheses to determine whether values influence beliefs regarding exports.

H1: There is a significant economic impact resulting from the difference between market energy prices and regulated prices set by the regulatory authority, affecting community outcomes for renewable energy investments, with specific emphasis on the SS Kitka wind energy project.

H2: The SS Kitka wind energy project will achieve a return on invested capital within a relatively short payback period.

H3: Variations in wind energy production (maximum, average, and minimum output) have a measurable impact on economic losses in the SS Kitka project?

2.2. Compensation of energy consumption and costs

Wind energy projects can generate additional economic benefits by reducing energy costs. Once deployed, wind turbines can directly offset a consumer's electricity consumption through a mechanism known as net metering. This concept enables wind turbines to be installed in proximity to a load, supplying power directly and thereby decreasing the amount of electricity purchased by consumers at retail rates. The quantity of energy not used by the domestic economy is credited to the consumer as it is returned back in the electricity system. A system of net metering policies varies, as it may be used for households or parks, schools and other community buildings, and large business or industrial facilities that use up many megawatts of electricity. The production of electricity in-house may also secure a hedge against potential increases in retail electricity tariffs.

2.3. An analysis of success stories in renewable sources

The SS Kitka wind energy production project comprises a system substation equipped with nine wind turbines, providing a total installed capacity of 32.4 MW. The 110 kV side of the system serves as a critical component within the energy network, acting as a robust and active balancing factor that

[1] https://www.gwec.net/

interacts with reactive power management. Meanwhile, the 10 kV side is designated for the distribution infrastructure, including lines, cables, and transformers. The performance of the system, as assessed through analysis and simulation using the Electrical Transient Analyzer Program (ETAP program), is evaluated concerning wind turbine integration and its impact on the electrical substation. Specifically, this study examines substation performance by analyzing voltage regulation and power losses when the wind turbines are integrated into the network operation.

The impact of a wind power plant on voltage control is primarily influenced by power flow dynamics within the network. The technical implications of integrating a wind power plant into the distribution network are evident in several key aspects.

Under normal operating conditions, when a wind power plant is not connected, the voltage at the busbar is lower than the voltage at the primary side of the transformer. However, disconnecting the wind power plant can induce a reverse power flow, leading to an increase in voltage at consumer connection terminals.

This voltage rise is a crucial factor limiting the integration of additional wind power plants into the transmission network. As the installed capacity of these units increases, a comprehensive voltage regulation analysis becomes necessary.

Furthermore, the connection of a large wind generator to a transmission network with insufficient strength can result in significant challenges related to power quality.

The ability of an induction generator to provide significant damping torque in the prime mover makes it well-suited for use in fixed-speed wind turbines. The squirrel cage induction generator (SCIG) is typically modeled as a PQ bus, where the active power (P) and reactive power (Q) demands are specified.

In transmission systems, the impact of wind power integration is highly dependent on the location of the wind generator relative to the load. The power balance equations governing this relationship are given by the fundamental principles of energy conservation, which equate the generated, consumed, and lost power within the system.

3. RESEARCH METHODOLOGY

3.1. Quantitative financial analysis

A rigorous financial analysis is conducted, employing advanced techniques in financial modeling, cost-benefit analysis, and ROI calculations. This phase uses mathematical modeling to simulate various wind energy production scenarios, considering factors such as energy output, capital expenditure, operational costs, and financing structures. The models will provide insights into the potential ROI across different investment periods and capital intensities.

3.2. Model treatment of financial impact

The financial impact intertwined to the work and cost of wind energy production is a suitable and useful tool in economic business. The models for wind energy include distributed wind. Based on project-specific data introduced by the user or predefined data (derived from industry norms), the model evaluates the operational and capital investments made in the SS Kitka project and the impact of these investments on the economic business, where as an investment chain may include: parts, equipment, work, workers, operations, etc. The contractual agreement between SS Kitka project with Energy Regulatory Office adjusted the price by setting €85 per 1 MWh. Table 1 shows the analysis of the assessment of financial impact on energy production, revenues generated and comparison of electricity price for the period January 2022 through August 2022. Subsequently, we have conducted variable-based analysis applied for the wind energy production conducted by the SS Kitka project for the period January 2020 to August 2022 through the variables used.

Table 1. Income based adjusted price compared to stock exchange price

No.	*Month*	*Quantity produced in MW/h*	*Adjusted price in €*	*Total monthly based adjusted price income*	*Energy based price exchange*	*Total value-based price energy exchange*	*Difference between adjusted values and energy exchange*
		A	*B*	*C = A x B*	*D*	*E = A x D*	*F = E - C*
1	January	9,225.87	85	784,199.46	205.04	1,891,672.38	1,107,472.92
2	February	8,517.26	85	723,967.10	194.55	1,657,032.93	933,065.83
3	March	7,635.37	85	649,006.45	285.96	2,183,410.40	1,534,403.95
4	April	9,082.02	85	771,971.70	189.44	1,720,497.86	948,526.16
5	May	4,217.43	85	358,481.55	205.11	865,037.06	506,555.51
6	June	5,433.41	85	461,839.85	237.11	1,288,315.84	826,475.99
7	July	6,538.65	85	555,785.25	371.59	2,429,696.95	1,873,911.70
8	August	5,912.24	85	502,540.40	495.95	2,932,175.42	2,429,635.02
	Total	**56,562.25**	85	**4,807,791.76**	**264.62**	**14,967,738.84**	**10,160,047**

Source: Authors' calculations.

3.3. Variables applied in the financial module

The treatment of the case has to do with an overall indicator that is used to perform an analysis of the financial model of energy production from the SS Kitka wind generator on the difference in the sale of energy according to the regulated price and the price of energy in the market for the period January–August 2022. Let us give an observation to the variables applied and the indices applied in their calculation.

Price Change Index Adjusted according to the Market and the Stock Exchange = *PCIAMSE*, calculated using the general formula:

$$NIVAPSE = SP \times AP = TBAPR - QP \times SEBP = TBSER \quad (1)$$

- *NIVAPSE* = Difference between input values, based on adjusted price and stock exchange.
- *QP* = Quantity produced.
- *AP* = Adjusted price.
- *TBAPR* = Total-based adjusted price revenue.
- *SEBP* = Stock exchange-based price.
- *TBSER* = Total-based stock exchange revenues.

NIVAPSE: This variable represents the difference between input values, which are adjusted for the adjusted price, and the price based on the stock exchange. It can be considered as a measure of the impact of the adjusted price compared to the market price (stock exchange), accounting for any variations in the market.

QP: This variable refers to the amount of energy produced, typically measured in units such as kilowatt-hours (kWh) or megawatt-hours (MWh), depending on the scope of the analysis. The quantity produced is a key factor that influences the revenue and profitability of energy production.

AP: The adjusted price is the price at which the energy is sold after considering factors like government subsidies, pricing policies, or other adjustments that affect the sale price of the energy, aside from the market price.

TBAPR: This variable represents the total revenue generated from the adjusted price. It is calculated by multiplying the adjusted price *(AP)* by the quantity produced *(QP)*.

3.4. Alternative method in research methodology

This method can be used to analyze the interconnection between macroeconomic variants and the financial performance of wind energy.

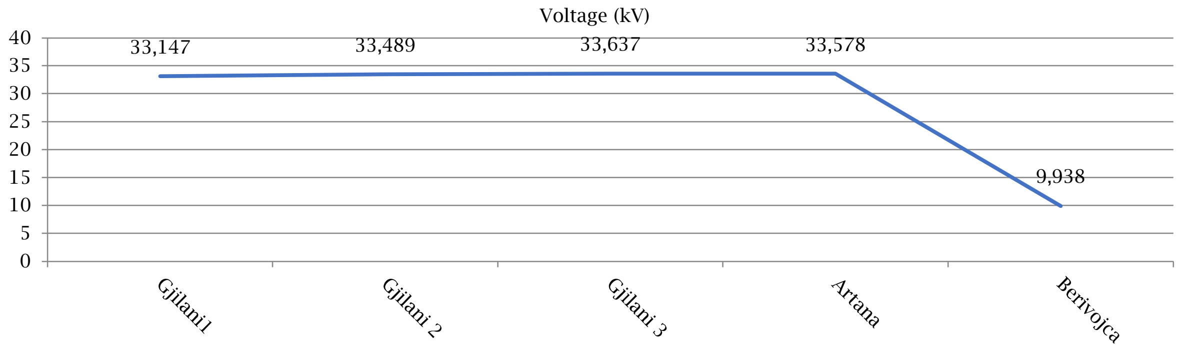
A regression model can be built to anticipate energy prices based on economic and trade factors.

General multiple linear regression model:

$$P_t = \beta_0 + \beta_1 X1_t + \beta_2 X2_t + \beta_3 X3_t + \varepsilon_t \quad (2)$$

where:
- P_t is the energy price at time t;
- $X1_t$, $X2_t$, $X3_t$, ... are economic and market factors;
- β_0 is the intercept;
- β_i are the coefficients of the economic factors;
- ε_t is the error term.

Figure 1. The profile voltage in some substations when wind turbine is not connected



Source: Authors' calculations.

Figure 1, it can be seen that without the connection of the SS Kitka wind park, the voltage on the 35 kV and 10 kV busbars is below the nominal value, i.e., they are 33.147 kV and 9.938 kV. These voltage values are acceptable according to the network code of Kosovo (10 kV,35 kV, and 110 kV) but as the load increases, then the voltage falls below the nominal values, and, in that case, the entire energy system is at risk.

The substations of the system are connected to each other through 110 kV, 220 kV, and 400 kV lines. The voltage and current values that are in the electrical substations when the turbines are switched on in the energy system are presented on the substations' busbars.

Below is a part of the electrical power system when the wind turbine is connected. At the moment of impact of the wind energy park, in this case, the wind speed is 12 m/s, and nine turbines are in operation.

The turbines are manufactured by the General Electric Company and the length of the turbines is with the dimensions:
- Rated power: 3,600.0 kW;
- Cut-in wind speed: 3.5 m/s;
- Rated wind speed: 15.0 m/s;
- Cut-out wind speed: 25.0 m/s;
- Survival wind speed: 57.0 m/s;
- Rotor diameter: 104.0 m;
- Swept area: 8,495.0 m^2;
- Number of blades: 3;
- Rotor speed, max: 15.3 U/min;
- Tip speed: 83 m/s;
- Generator type: Double Fed Asin;
- Number: 1;
- Speed, max: 1,800.0 U/min;
- Voltage: 690.0 V;
- Grid frequency: 50 Hz.

4. RESULTS

The results from *H1* provide strong evidence of the economic and financial advantages of the SS Kitka wind energy project, particularly in terms of cost savings and economic development for Kosovo. The analysis of wind energy production from January to August 2022 demonstrates that the project has significantly contributed to reducing public expenditure on energy procurement. By producing 56,562.25 MWh during this period, SS Kitka not only generated renewable energy but also played a crucial role in stabilizing the national energy supply.

One of the key observations from the analysis is the substantial difference between the regulated price of €85 per MWh, set by the Energy Regulatory

Office of Kosovo, and the fluctuating market prices on the stock exchange, which ranged from €189.44 to €495 per MWh. This price disparity highlights the cost-effectiveness of domestic wind energy production, as opposed to reliance on imported electricity. The total market value of the wind energy produced during this period, calculated using the average stock exchange price of €264.62 per MWh, reached approximately €14,967,738.81. This resulted in a direct economic benefit to the government of Kosovo, estimated at €10,160,047.

From a financial perspective, the SS Kitka company generated a revenue of €4,807,791.76 based on the regulated price of €85 per MWh. However, this amount represents a deficit compared to the stock market valuation, further reinforcing the importance of optimizing market conditions for renewable energy projects. The profitability of such projects could be enhanced by aligning domestic energy pricing mechanisms with market trends or introducing additional government incentives for wind energy investors.

Beyond the financial benefits, the results indicate that the SS Kitka project has broader socio-economic and environmental impacts. The local community directly benefits from the project through job creation, improved energy security, and opportunities for economic diversification, particularly for local businesses such as landowners, ranchers, and service providers. Furthermore, the project contributes to environmental sustainability by reducing reliance on fossil fuel-based electricity, thereby lowering carbon emissions and promoting cleaner energy alternatives.

In summary, the SS Kitka wind energy project has proven to be a financially viable and economically beneficial initiative for Kosovo. The significant cost savings generated through wind energy production, coupled with its contributions to community development and environmental sustainability, highlight the importance of further investment and policy support for renewable energy projects in the country. Future research could focus on optimizing pricing mechanisms, assessing long-term economic impacts, and exploring additional community benefits to enhance the effectiveness of wind energy projects.

Environmental benefit is that wind energy contributes to a cleaner environment by reducing carbon emissions and decreasing dependence on fossil fuels, aligning with global sustainability goals.

Table 2. Impact of capital investments for wind energy production from January to June 2022

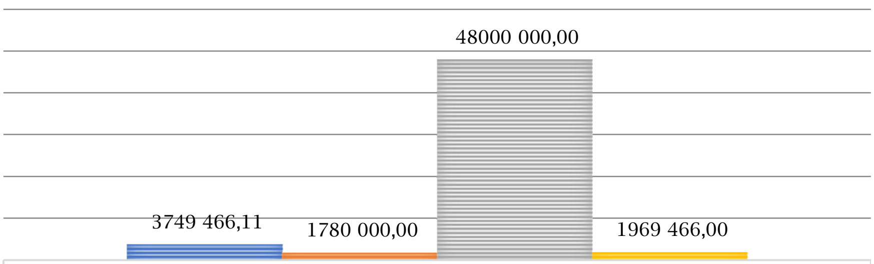
No.	***Month***	***Revenue by value***	***Operating expenses***	***Total project investment***	***ROI minus costs***
		A	*B*	*C*	*D = A - B*
1	January–June 2022	3,749,466.11	€1,780,000	€48,000,000	€1,969,466.11

Source: Authors' calculations.

From the Table 2, based on the calculations presented for ROI and added value, income from structured investments were calculated and presented above. For each investment made, the duration of the ROI and the value of the annual instalment will be determined in such a way as to fulfil the return of the investment (principal) by affecting the added value.

Based on the fact that the production of wind energy is very economical and favourable for the country, Energy Regulatory Office (ERO), after carefully analyzing all the factors, came to the proposal that the duration of the Agreement for the Purchase of Wind Energy should be 12 years at a price of €85 per MWh. This has influenced the encouragement of foreign investors for the construction of projects for the production of wind energy.

Figure 2. Investment period from January to June 2022



Total revenues	3749 466,11
Operational ecpenses	1780 000,00
Value invested in the project	48000 000,00
Return on investment	1969 466,00

Note: Results from H2: Model for calculating the return on capital investment.
Source: Authors' calculation based on investment period January–June 2022.

Figure 2 shows the financial model is based on modeling that aims to provide a combined overview at the investment level, for individual financing instruments, where these certain financial instruments might affect the terms of ROE investment, which are incorporated by applying the cost level average in relation to income and the value of invested capital.

The investment calculation model is applied using the net income method.

According to the net income method, the value of the invested cost and the total value of the income from the investment made were applied.

$$ROI = (Net\ icome/Cost\ of\ investment) \times 100\% \quad (3)$$

The income for the period January–June 2022 was in the amount of €3,749,466.11.

The cost of operating expenses for the period January–June 2022 was in the amount of €1,780,000.

$$ROI = (3{,}749{,}466.11/1{,}780{,}000) \times 100 = 200\% \quad (4)$$

According to Figure 2, the cost of investment has a very high return benefit, where the benefit is up to 210%, the ratio of cost to income. Based on the results, the investment had a high-profit performance, which positively affects the return on capital.

Model of calculation formula:

- I = Total investment in years t;
- RP = Revenues for the period;
- ROE = Return on equity investment;
- OC = Operating costs;
- NP = Net profit.

Where ROI and ROE are calculated based on the following formula:

$$IKE = (tp - ko) = fn\ \frac{i}{t} = KIE \quad (5)$$

This method enables the calculation of percentage of the investment through the current operating cost:

$$ROI = (Revenue - Cost)/Cost \times 100 \quad (6)$$

$$ROI = (3{,}749{,}466.11 - 1{,}780{,}000)/1{,}780{,}000 \times 100 = 1{,}969{,}466.11/2 = 3{,}938{,}932.22 \quad (7)$$

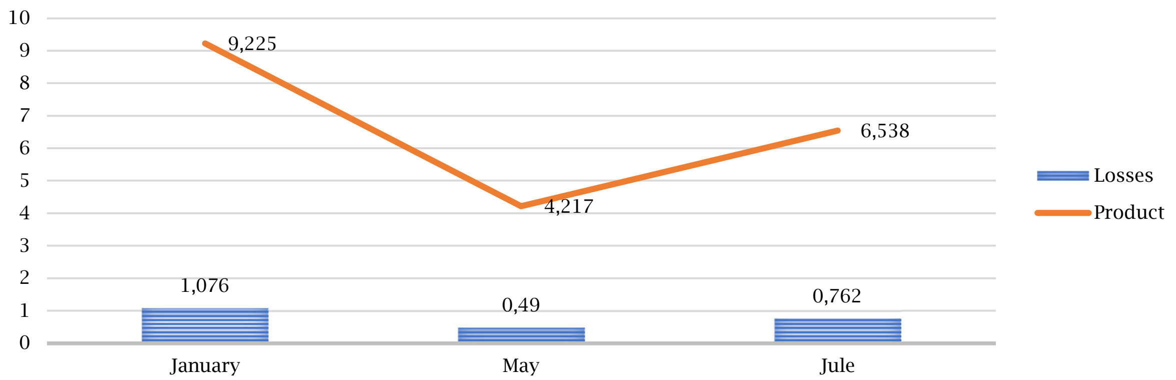
$$ROI = 48{,}000{,}000/3{,}938{,}932.22 = 12\ years$$

Based on the calculations presented in the investment return and added value section, it is predicted that for the invested value of 48 million euros, the impact of the return on capital investment based on the annual value is €3,938,932.22, and taking based on this value of the capital impact, then it means that for 12 years the investment made in the SS Kitka project is fully returned. Figure 3 shows the power flow as well as the energy losses in all elements of the network, such as transformers, cables, and overhead lines.

The result from *H3* is that the higher the intensity of the wind, the greater the energy production. In cases where the wind is at its optimal speed quota, the turbines are able to produce energy up to its maximum capacity of 32.4 MWh, where for this quantity produced, the impact of losses in kilowatts is 3.78 MWh.

The simulations are conducted using ETAP software to calculate the active and reactive power losses for the scenario where the energy park's generators operate at maximum production. In this case, the active power losses amounted to 3,780.4 kWh, equivalent to 3.78 MWh.

Figure 3. Active losses in the network in relation to energy production from turbines



Source: Authors' calculation using ETAP software.

Figure 3 shows the production of energy from the turbines in the amount of 9,225 MWh and for this produced amount of energy there are active losses that are 1,076 MWh. Based on the results obtained in relation to the calculated losses, the financial impact varies depending on the adjusted price and that according to the stock market. Based on the reference values, we find that the value for the calculation of losses is accomplished as follows.

According to adjusted price:

$$x = 1{,}076 \times 85 = 91{,}460€ \quad (8)$$

If we produced 9,225 MWh at the price of 85 = €784,125, the discounted value for transmission losses is €91,460, and the net value of the energy received by the consumer is 8,149 MW/h or €692,665. The research done for the SS Kitka project and according to the analysis and discussions on this matter revealed that properly located and operated wind turbines increased environmental and economic benefits for the communities expecting the development of renewable energy in particular and for the country in general. However, the need for extensive land use for wind parks causes negativity in nature conservation. Wind parks are reported to kill millions of birds every year around the world, and many of them are eagles, swans, geese, storks and other protected species. Based on the results obtained and presented in relation to the financial impact on investment return.

The connection between the turbines is with a cable with a section of 150/25 mm2 type (XLPE-AL), while the connection with the 20 kV substation is with a cable with a section of 300/25 mm2 (NA2XS(F)2Y.

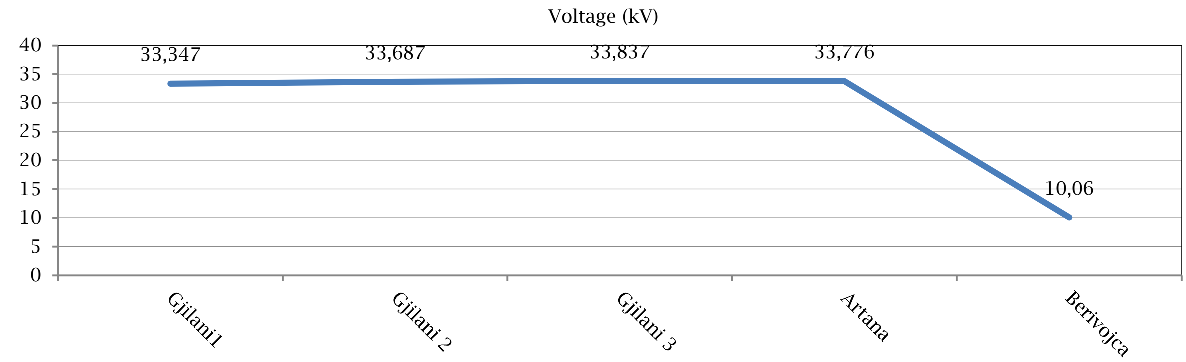
According to the code of the electrical equipment in Kosovo system voltage limits are permitted according to Table 3 shown below.

Table 3. Voltage in normal and extreme conditions

Voltage level (kV)	*Voltage in normal condition*		*Voltage in condition extreme*	
	Min voltage	*Max voltage*	*Min voltage*	*Max voltage*
400 kV	380 kV	420 kV	360 kV	440 kV
220 kV	209 kV	231 kV	198 kV	242 kV
110 kV	99 kV	121 kV	88 kV	130 kV

With the installation of wind turbines, the voltage profile on the busbars improves, and affects the quality of energy received by consumers. The voltage value on the Gilani busbar (substation) is 34.542 kV, which is close to the nominal value according to the distribution network code, which is 35 kV. Similarly, the voltage value on the Berivojca substation busbar increases to 10.06 kV, which is above the nominal value of 10 kV.

Figure 4. The profile voltage in some substations when wind turbines are connected



Source: Authors' calculation.

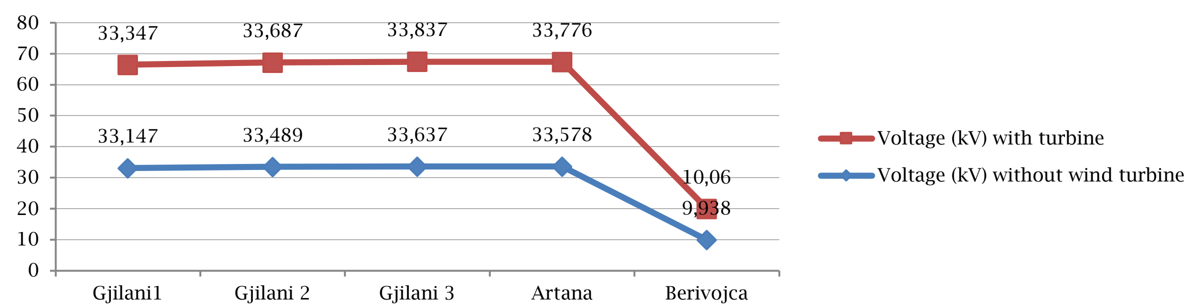
By comparing the voltage on the busbars with the voltage that is allowed in the network of the electricity system of Kosovo, it can be seen that for the loads presented in the system, the voltage is within the limits allowed according to the network code of Kosovo.

In the case of the connection of the wind energy park through 19.6 km long conductor with a conductor section of 240/40 mm2 to the Berivojca 110/10 kV substation, in which substation there are two energy transformers with a power of 20 MVA and which work in parallel work, the improvement of the voltage in all the busbars of the electric power system is achieved. Raising the voltage level also affects the reduction of losses in the distribution system.

Therefore, when the turbines are switched on, the voltage value in these busbars increases by 34.542 kV and 10.06 kV, which are shown in Figure 5.

With the connection of the wind energy park in SS Berivojca, the reliability of the supply of electricity to this region increases, and this also helps in the economic development of this region.

Figure 5. Comparison of busbar voltage when wind turbines are connected and when they are not connected



Source: Authors' calculation.

The results of the voltage profile are taken from Figure 1 and 4 while the difference of busbars in 35 kV and 10 kV voltage of the power system is presented in Figure 5.

5. DISCUSSION

Review of renewable energy literature emphasizes the importance of strategic investment in wind energy as a sustainable economic and environmental solution. Various studies have shown that wind energy production contributes to reducing dependence on energy imports and improves the energy safety of a country. Accordingly, the results of the Energy Project Analysis of SS Kitka confirm the economic and financial benefits of this model, providing significant savings for the public sector and stabilizing the power supply in Kosovo.

Empirical results show a low cost of domestic wind energy production compared to electricity market prices. This matches the findings of the literature, which emphasize that wind energy can be more competitive if supported by appropriate price policies and additional incentives for investors. Moreover, the ROI of 210% and the 12-year period of capital return show strong financial sustainability, reinforcing the arguments of previous studies on the long-term benefits of wind energy projects.

From an environmental and socio-economic perspective, the SS Kitka project offers tangible benefits to the community, creating jobs and supporting local economic diversification, as suggested in the literature. However, the study also highlights potential challenges, such as the impact on biodiversity and network energy losses, which must be managed to optimize net project benefits.

Considering these findings, it is clear that the development of wind energy projects in Kosovo should be associated with favorable price policies and improved regulatory mechanisms to maximize economic benefits and reduce adverse impacts. In the future, research can focus on improving the energy price model, analysing long-term economic impact, and reviewing methods for reducing energy losses and ecological impacts.

6. CONCLUSION

Wind power generation is increasingly prominent within transmission networks, necessitating a robust strategy to evaluate and manage the impact of wind generators at various connection points. Such a strategy is essential to maximize the benefits of wind energy integration within the broader power system. This paper addresses the financial impact of renewable investments, specifically examining the SS Kitka wind park project. By analyzing business models for citizen participation within Kosovo's renewable energy sector, the study reveals that the primary beneficiaries of these investments are both the local community and the country of Kosovo.

This research focuses on the operational impact of integrating the SS Kitka wind park, with an installed capacity of 32.4 MW, into the distribution network in the SS Kamenica region via the SS Berivojca. Simulation results reveal that the wind park significantly influences the voltage profile, system losses, short-circuit currents, and overall network stability. The findings indicate that voltage instability is more pronounced in networks with distributed generation compared to conventional systems.

This study's findings emphasize the significant economic, social, and environmental impact of wind energy production, with a specific focus on the SS Kitka project. The findings demonstrate that Kosovo, as a state, is the primary economic beneficiary of this renewable energy initiative due to the considerable cost savings and revenue generation opportunities associated with wind power. The analysis of energy production from January to August 2022 shows that the SS Kitka project generated 56,562.25 MWh, with a regulated price of €85 per MWh, leading to a turnover of €4,807,791.76 for the company. However, due to fluctuating stock market prices, ranging from €189.44 per MWh to €495 per MWh, the project had a potential revenue gap of €10,160,047, which ultimately benefited the government. If assessed based on the average stock market price of €264.62 per MWh, the total value of SS Kitka's energy production would be €14,967,738.81, demonstrating the strong economic potential of wind energy investments.

Beyond the financial aspects, the project has substantial socio-economic benefits. The introduction of wind energy infrastructure contributes to job creation, strengthens energy security, and provides new income sources for landowners and local businesses. Additionally, the transition to wind energy fosters environmental sustainability by reducing reliance on fossil fuels and lowering carbon emissions. This aligns with Kosovo's broader energy transition strategy and supports long-term sustainability goals.

In conclusion, the SS Kitka project serves as a model for the economic and environmental viability of wind energy in Kosovo. The financial savings, energy security benefits, and sustainability improvements underscore the importance of expanding wind energy initiatives across the country. To maximize the benefits of such projects, it is essential to refine policies, enhance community engagement, and continuously monitor the long-term impacts of renewable energy developments. By doing so, Kosovo can further strengthen its position as a leader in renewable energy adoption and ensure a more sustainable future for its economy and environment.

In the context of Kosovo's energy landscape over the next decade, there is a clear need for substantial long-term investment in renewable energy sources (RES), driven by the country's heavy reliance on coal. This dependency limits Kosovo's capacity to meet consumption demands reliably and increases the need for energy imports.

Based on the calculations presented in the investment return and added value section, it is predicted that for the invested value of 48 million euros, the impact of the return on capital investment based on the annual value is €3,938,932.22, and taking based on this value of the capital impact, then it means that for 12 years the investment made in the SS Kitka project is fully returned.

One limitation of this research is the lack of extensive feedback from the local community regarding the environmental impacts of the SS Kitka project. Specifically, there is insufficient data on how the project affects wildlife and community safety, which are critical factors in assessing the overall sustainability of wind energy developments. To address this gap, future research should incorporate a broader range of community perspectives, including input from residents, environmental experts, and local authorities. By doing so, researchers can develop a more comprehensive understanding of the social and ecological implications of wind energy projects in Kosovo, ultimately contributing to more informed decision-making and sustainable energy planning.

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