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Efficiency of wind turbines and sustainable development in Kitka Park – Case study

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ABSTRACT

This paper analyzes the efficiency of generators with a focus on promoting wind turbine components and practical investment strategies. The turbines utilized in Kitka Park represent the latest technology, featuring tower heights of 110 meters. The average annual wind speed under optimal conditions ranges from 6.4 to 7.5 m/s. A key achievement of this project is the reduction of 75.000 tons of CO_2 emissions, primarily through decreased reliance on fossil fuel combustion. The primary objective of this study is to enhance wind turbine performance by improving the power factor of installed generators, as assessed through measured and simulated parameters. The case study demonstrates a 3% increase in turbine generating performance at a height of 120 meters. The generating capacity of the existing turbines is 3.6 MW; with an increase to 4 MW, efficiency per turbine has improved by 9%. The enhancement in generating power yield is identified as a critical factor influencing the operational performance and functional interaction of wind turbines.

Keywords: wind turbines, power sequence, digital technology, noise effect, environmental sustainability.

INTRODUCTION

The introduction of wind turbine technology in the Kosovo market has eliminated barriers in the renewable energy sector, paving the way for a sustainable development approach. (Vehebi, 2017). The implementation of wind turbines has helped reduce the pressure to meet energy consumption demands, which continue to grow daily (Seaver et al., 2023). Kosovo possesses over 10 billion tons of coal, ranking fifth globally in terms of coal reserves. The total capacity for coal-fired electricity generation in Kosovo is 1.110 MW. According to European Directive legislation, energy production from fossil fuels is undergoing a transition toward CO_2 decarbonization, with full implementation targeted by 2050 (European Commision, 2024). Residents and habitats in the region are significantly influenced by socio-economic factors, which also impact recreation and tourism development. To address key challenges and promote the sustainable growth of wind energy in the Republic of Kosovo, it is recommended to develop innovative solutions through various scientific initiatives and the establishment of information centers (Copping et al., 2020). The proposed energy strategies aim to gather innovative solutions through various scientific activities and the establishment of information centers to address key concerns and support the sustainable growth of wind energy in the Republic of Kosovo (Florescu et al., 2019). To mitigate the effects on wild habitats in the area of the Kitka wind turbine park, it is recommended to implement a series of activities grounded in scientific information to avoid environmental impacts. These efforts should support sustainable development through a transition bolstered by incentive policies, regulatory measures, and tariff adjustments (Rahman et al., 2022). The main factors contributing to the security of investments in new technologies include energy efficiency, stability in energy infrastructures, and the positive impacts of energy generation. These factors are reflected in market interest rates and the fulfillment of profitable preconditions (Shabalov et al., 2021). Kosovo is one of the most favorable countries in Europe and the youngest country in the world. It also has a significant resource of lignite. The most effective source of renewable energy generation is wind, which turns turbine blades through lines of wind waves (Sofiu et al., 2022). The global energy crisis has affected the fluctuating prices of electricity and natural gas generation and has directly affected the dynamic plan of strategic forecasts for renewable energy sources. The dynamism is mainly oriented towards the use of new technology in reducing the exposure of imports at the peak time when fossil fuel generation is in the phase of exposure of regulatory capacities for the near future. The paper presents the sustainable strategy related to the complex effects that surround the promotional and environmental policy-making where the wind turbines are located and their settlements in the impact on the environmentalist life (Arnett et al., 2016). The integration of a unified market between Kosovo and the countries of the region represents a strategic opportunity to enhance system planning through shared user capacities. This collaborative planning approach promotes sustainable development within the broader pan-European market, ensuring a secure electricity supply for both residential and commercial consumption. By aligning practical goals with strategic objectives, the implementation plan outlines concrete actions, as illustrated in Figure 1. These actions focus on improving energy efficiency and diversifying the use of energy resources, contributing to the region's energy resilience and sustainability (ICS, 2022).

Figure 1 illustrates a closed system for controlling and managing the conversion of wind energy into electricity. This system features automatic and synchronized monitoring of various operational parameters. The turbine blades utilize the cross-section of wind lines, with each component closely monitored and measured by a speed sensor. The speed sensor serves as a key factor in regulating the intensity of the energy produced, ensuring efficient and stable operation (Widuto, 2023).

Turbine components: L-auxiliary mechanism for optimizing energy conversion; K-yall- wind speed control management element; SOE - is part of the system that helps to conserve energy and regulate the generated energy; GJ- is the generator that converts the mechanical energy of the turbine into electrical energy, K: is the controller of the energy and components of the automatic system. All elements of the system are synchronized with each other in order to optimize the efficiency of the electricity generation process and it is sent to the grid which is used for consumption (Sankalpa et al., 2024). The paper presents the possibilities of technological use of increasing performance with the main components of wind turbines (Rahman et al., 2015).

RESEARCH METHOD

The paper provides an analytical description of the generating capacity of wind turbines, analyzing the comparison of data with the main project in terms of feasibility and the actual condition of the Generating Park in Kitka. Wind speed measurements in the park were taken using the FT743-SM sensor, which was mounted on a drone. The geographical positions of the turbines are

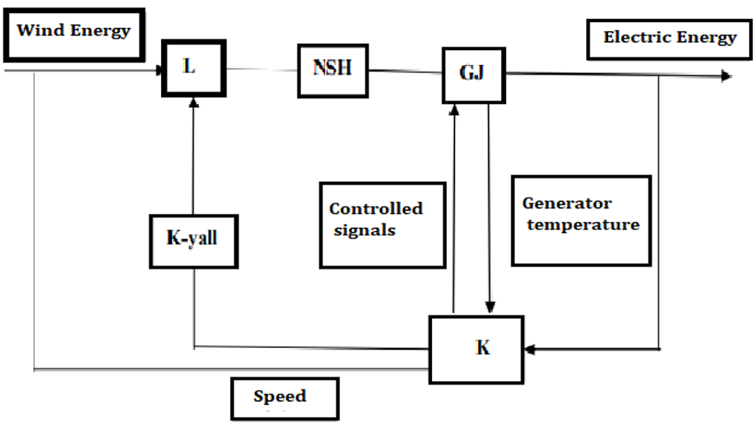

Figure 1. Scheme of the system for converting wind into electricity

determined based on the measurement coordinates where the GPS-derived results were obtained. The analysis of electricity generation focuses on the operating periods of each turbine, considering their monthly generating performance in the park. This also includes an assessment of sustainable development, accounting for the environmental impact (Olabi et al., 2023).

This paper describes the technology used in the Kitka park as a new technology in Kosovo and the possibilities of meeting the demand for electricity according to the strategic energy plan. Various wind turbine concepts have been developed and built to maximize wind energy production while minimizing turbine cost and increasing generation efficiency and reliability (SE, 2012). There are three main factors that affect the amount of wind energy production: wind speed, air density and the area involved. Kinetic energy is transferred to an energy storage system whenever an object of a given mass is in motion at a rotational speed. When the air is in motion, the kinetic energy of a generating turbine is calculated according to the formula (1), which represents the energy that the object has due to its movement. This is a physical representation of the rotating potential of turbines that in a physical sense involves mechanics and energy (Smith et al., 2021).

$$P_{in} = \frac{1}{2} \cdot \rho \cdot A \cdot v^3 \quad (1)$$

where: P – electrical energy (W or J/s); m – mass (kg); v – volume (m^3); ρ – air density (kg/m^3), which is typically approximately 1.225 kg/m^3 at sea level; A – the surface that is traversed by the wind (m^2), which is the surface of the wind turbine; v – wind speed (m/s).

The function of the turbine depends on the speed of the wind which flows as a fluid in motion closely related to the air mass for the given rotating surface. To show the yield with the physical connection of the turbines, the factor between the energy produced and the energy received from the wind source is calculated with formula (2).

$$\eta = \frac{P_{out}}{P_{in}} \quad (2)$$

where: η – is the efficiency of the turbine (unit is percentage); P_{out} – is the electrical energy produced by the turbine (W or J/s); P_{in} – is the energy that can be obtained from the wind (W or J/s).

The connections of the empirical formulas with the electronic measured wind speed data are closely related to the height level of the turbine mast from 80 m to 110 m, taking into account the air density and the efficiency of the turbine.

When wind passes through a wind turbine, as described by formula (3), and drives the blades to rotate, the corresponding wind mass flow rate is:

$$m = \rho \cdot v \quad (3)$$

where: ρ – densitety (kg/m^3).

Another important parameter that directly affects the production of wind energy is the air density, which can be calculated from the equation of state (4):

$$\rho = \frac{P}{RT} \quad (4)$$

where: p – absolute pressure (Pa); R – specific gas constant for dry air J/(kg·K); T – absolute temperature (K).

Wind speed is one of the most important factors in electricity production. In fact, wind speed varies both over time and across space, as described by formula (5), and is influenced by various factors such as geographical conditions and weather (Suresh, 2013).

Demands for generating stability are closely related to the strategic objective which contributes to meeting the demands for electricity. In order to respond to the challenges of sustainable development, Kosovo has prioritized wind energy sources as a replacement for energy generation with fossil fuels.

KITKA Park is implemented according to the infrastructural conditions of the system in the built-up area. The operational turbines reflect the analysis of power yield formula (5) and maximum wind energy generation formula (6).

$$\frac{V_2}{V_1} = \left(\frac{H_2}{H_1}\right)^{\alpha} \quad (5)$$

where: H – height, v – speed.

The yield shows that the efficiency of the converted energy depends on many factors including the design of the turbine in order to reduce the mechanical losses which are around 33%.

Harmonizing the concept of the block diagram with the yield system operator is related to the conversion of mechanical energy from a rotating source, such as wind energy, into electrical energy by a wind turbine designed in the perfect technological form. For wind turbines, efficiency can be calculated as the ratio between the energy produced and the energy that is potentially taken from the wind source (Musyafa et al., 2011).

$$P_{pr} = C_{max}\frac{1}{2}\rho \cdot A \cdot v^3 \quad (6)$$

where: C_{max} – max of wind energy; ρ – air density; A – turbine area; v – vind speed.

The speed of wind in turbines is dependent on the flow of windfront speeds creates the communication report intermediate intermediaries of turbine and the motorcycle of the rotor which are connected to the critical elements of energy generation formula (7) with time productivity per day.

$$E = P \cdot \tau \quad (7)$$

Geographical position where the wind turbines are located in Kitka Park provide environmental sustainability from the noise of the turbines where are live residents and pastures of livestock and fauna. The complex provisions of the mountain spaces change the flow of wind brakes in the turbine helix according to the points where turbines are installed. The orientation and direction of the 9 turbines are located in Latitude 42° 39' 58.9" and Longitude 21° 40' 43.2" with the geodetic system WGS84. The turbine pillars are located from 960 m to 1050 m above sea level with notes according to Table 1. Turbines are located in horizontal position with three rotating wings with 136 m in diameter. In Kitka Park, the geographical position enables the installation of 22 other turbines with an installed power of 3.6 MW or a total of 79.2 MW. If the turbines are installed with a power of 6 MW or a total of 132 MW, we will have efficiency with an increase of 66.7%. Nominal power increase according to Table 1 for each turbine is estimated to be 6 MW with a significant increase compared to the existing condition. The height of the turbine of 120 m according to the case study configures the current generation and clearly permits the generating performance of the speed of the sand. In this way, we have significantly increased the overall generation potential without increasing the number of turbines.

Table 1. Description of the existing turbines and study case turbines

Feature	Existing turbines	Study case turbines
Number of turbines	9	9
Type of turbine	GE-3.6 - 137	V150-6.0
Rated power (per turbine)	3.6 MW	6 MW
Total ınstalled capacity	32.4 MW	54 MW
Hub height	110 m	120 m

Monitoring and control of the system from the operating scada shows the generating participation from 21% to 49%, the turbines generate 29% of the power installed per year. Analytically, the optimal amount of wind generating efficiency is when the output speed is about 1/3 of the wind speed as a generating factor. This makes sense only when wind yields are at 10 m/s speed, while efficiency is maximum by excluding generation losses compared to theoretical limit. According to European Directives (2014/52/BE).

Kosovo has raised the level of environmental sustainability exposure by introducing legislation in force with regulations in support of clean wind energy technologies. The fulfillment of the goals in this paper is closely related to improving and reliability of the system's flexibility and the state of good energy efficiency.

RESULTS AND DISCUSSION

Wind is an inexhaustible source of electricity generation, with power capacity varying by region. Technical conditions determine the utilization of wind potential by analyzing precise wind speed histograms at the heights where wind turbines are installed (SERK, 2022). Greater turbine height enhances generating performance, enabling the blades to capture more efficient wind flows. According to measurements by the Hydrometeorological Institute of Kosovo, the Kitka Park location is well-suited for the installation of wind turbines (IHMK, 2022). According to the results, consistent differences are observed between scenarios, particularly concerning wind speed variations with turbine tower height, as shown in Table 2.

As shown in Table 2, the autumn months (September and October) have higher wind speeds, with an average of 8 m/s. This variation is typical for the seasonal period, indicating an increase in wind activity during this time. On the other hand, the lowest wind speeds are observed in the winter months (November and December), where the data shows a noticeable drop in the average for all height levels, indicating that wind speeds are lower during this period. The highest altitude is always the most efficient, generating more electrical energy. Specifically, the

Table 2. Simulative measurements of the wind speed according to altitude above the ground level

Month	H_1/120 m	H_2/110 m	H_3/100 m	H_4/90 m	H_5/80 m	Simulim (Log) H_5/8 0m
September	8.33	8.24	8.12	7.81	7.62	7.74
October	8.72	8.55	8.43	8.22	7.91	8.09
November	8.15	7.95	7.81	7.71	7.63	7.65
December	6.93	6.77	6.74	6.65	6.62	6.74
January	7.25	7.11	7.05	6.95	6.93	6.95
February	7.85	7.81	7.75	7.72	7.63	7.65
March	5.93	5.85	5.75	5.65	5.62	5.65
April	7.33	7.25	7.15	7.12	6.95	7.06
The average	7.54	7.42	7.32	7.22	7.11	7.26

highest wind speed was observed at the height of 120 m (H_1), with an average of 7.54 m/s, while the lowest values were recorded at the height of 80 m (H_5), with an average of 7.11 m/s. This difference is critical for determining the optimal placement of the turbines and maximizing energy efficiency. Furthermore, the wind speed data from the simulated (Log) model at 80 m (H_5) closely matches the actual measurements in most months, with slight differences observed in March and April. This suggests that the logarithmic model is a reliable tool for predicting wind speed and can be used to optimize turbine placement and improve energy generation performance. These changes are essential to consider for further modeling of turbine performance and optimizing capacity in future installations. The geographical positions of suitable areas where wind turbines are located show that the energy generation efficiency for an 80-meter tower height is 37.6%. (Osmani et al., 2018). These variations are essential to consider for further modeling of turbine performance and capacity optimization in future installations. The FT743-SM sensor mount demonstrated strong performance, with the WR-3 Plus precision wireless anemometer functioning effectively at distances of up to 500 meters above sea level, providing reliable data for accurate wind speed measurements. Column of Table 2 with simulation (Log) H_5/80m presents the simulation of the initial height using a logarithmic model that calculates the wind speed at the maximum height of 120m, calculated according to the standard formula. For this, the logarithmic formula or the exponential wind law for platform simulation according to formula (8) is usually used.

$$v(z) = v(z_0)^{\circ}\ln(\frac{z}{z_0}) \quad (8)$$

where: z – altitude of interest (eg, 80 m); z_0 – reference height (eg, 120 m); $v(z_0)$: velocity measured at z_0.

The diagram of Figure 2 presents the wind speed according to heights from 120 m to 80 m for each month in average values.

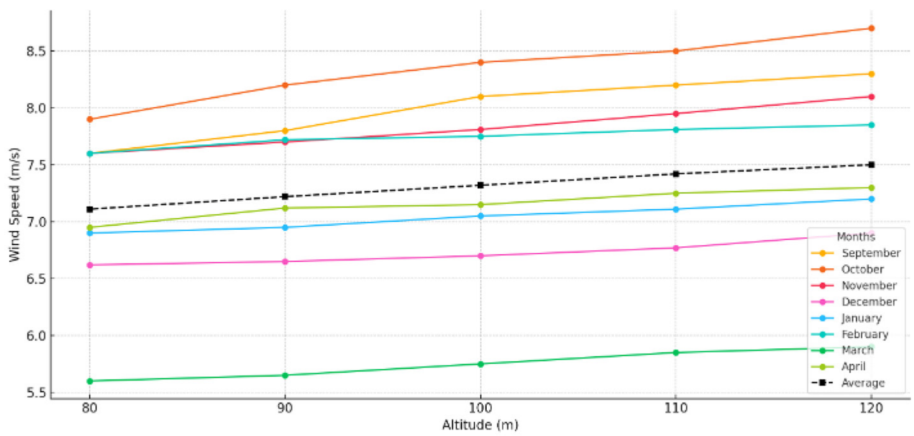

Figure 2. Diagram of wind speed measurements according to the heights of the wind turbine poles

The data from Table 2 are also depicted in Figure 2, which illustrates a typical wind speed distribution, clearly showing the impact of height and seasonality. The simulations align well with the actual measurements, confirming the validity of the models used.

The technology deployed at Kitka Park has the potential to enhance the efficiency of new generating capacities in the nearby installation area. By installing turbines with power units ranging from 4 to 6 MW, in line with the latest development trends and efficiency improvements, the efficiency could increase by 11.36% to 66.7%. Increase performance in generating efficiency harmonizes balancing controls of the cutting edge of turbine roofing wings from land level (Dusan et al., 2006). Table 3 shows the generation of wind turbines in MWh for 2023, which is compared to the installation power of the turbine in operation.

From Table 3, it is evident that the turbines exhibit varying performance levels in electricity generation. These measurements suggest that the generators should be optimized to meet the requirements for the values shown. The T04 turbine achieves the highest efficiency at 39.06% and demonstrates the best generation performance. In contrast, turbines T03 and T06 show weaker performance, and technical interventions may be necessary to boost their energy production. Further optimization of the generators will significantly increase production and contribute to the sustainable development of efficiency at Kitka Park. The measurement verification indicators, derived from the collection of analytical formulas and electronic measurements between the generating operator and the electricity distribution operator, reveal an average generation efficiency of 32.08%. Wind speed is influenced by meteorological factors and the height of the towers for generating turbines (Radzka et al., 2019).

The data from Table 3 are presented in Figure 3 for electrical energy efficiency, where the

Table 3. Efficiency of generating turbines

Turbine	Produced energy (MWh)/2023	Installation power (MW)	Effectiveness (%)
T01	9.722.24	31104	31.25
T02	9.526.235	31104	30.62
T03	9.114.309	31104	29.3
T04	12.152.250	31104	39.06
T05	9.496.480	31104	30.49
T06	9.208.635	31104	29.6
T07	10.394.550	31104	33.42
T08	9.760.564	31104	31.38
T09	10.458.328	31104	33.62
Average		32.08	

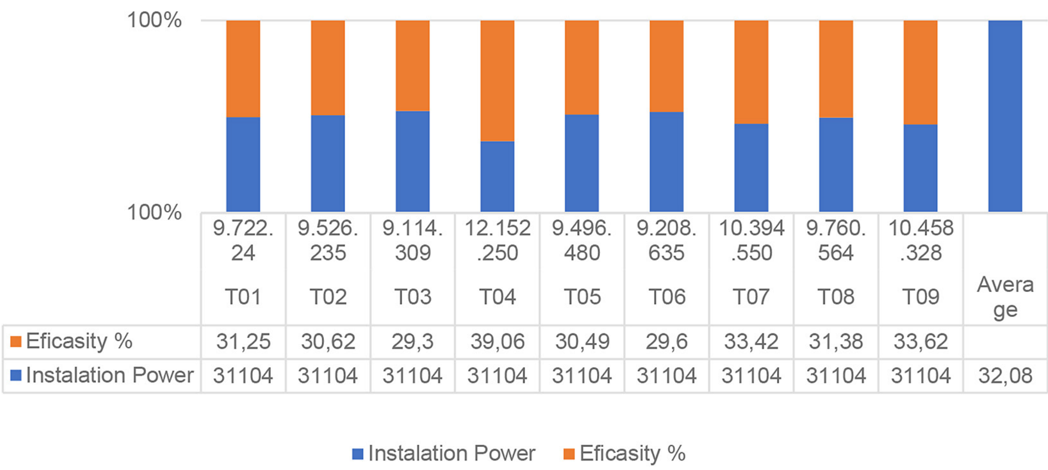

Figure 3. Energy efficiency diagram

electronic measurements determine the accuracy of the performance through the coefficient of the generating turbines. Table 4 presents electronic measurements indicating an annual generation performance of 33.28%. The turbine performance efficiency diagram, illustrated in Figure 4, is based on generation data from Table 4.

Based on the diagram in Figure 4, the electronic measurements for wind speed range from 5.62 m/s in March to 8.55 m/s in October, indicating rotational stability in the rotor measurement coefficient, accompanied by a slight increase in energy production. Meteorological data further confirm that turbine height significantly increases system efficiency, surpassing the traditional method of vertical exploration based on the power law, as determined through direct measurement methods. These findings align with the results of (Maulana et al., 2024), emphasizing the importance of turbine height and technical optimization in improving turbine performance.

Figure 5 illustrates the comparison of efficiency between the years 2023 and 2024, where measurements combined with mathematical statistics have shown that the operational efficiency of a turbine is approximately 30–40%. In 2024, the efficiency is notably higher. This comparison aims to analyze the analytical efficiency in alignment with approximate electronic data for both scenarios of low wind speed conditions and optimal wind speed conditions. The data highlight that the advancements in turbine technology and operational adjustments in 2024 have contributed to improved efficiency, especially under varying wind speed scenarios (Chen et al., 2021). These results are important for understanding how turbine placement can be optimized in order to achieve maximum generation performance. The choice of the height of the turbines and their adaptation to the specific wind conditions are key to increasing the efficiency of the energy system. Increasing the height of the turbines will enable the wind to be

Table 4. Efficiency of generating turbines for 2024

Turbine	Produced energy (MWh)/2024	Installation power	Effectiveness %
T01	10.487.244	31104	33.71
T02	10.497.976	31104	33.75
T03	12.883.560	31104	41.14
T04	9.100.264	31104	29.25
T05	9.630.072	31104	30.96
T06	9.648.196	31104	30.19
T07	10.594.952	31104	34.06
T08	10.206.880	31104	32.81
T09	10.475.317	31104	33.67
Average		33.28	

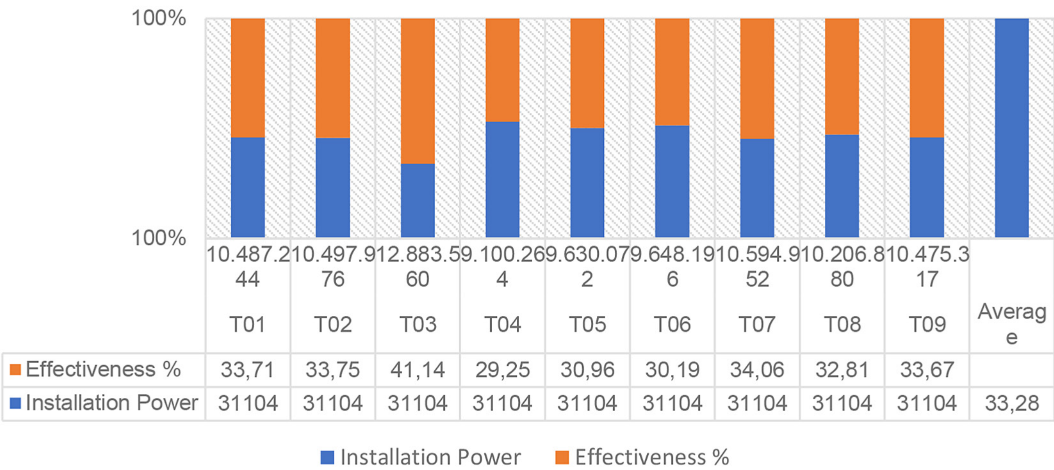

Figure 4. Diagram of energy production efficiency

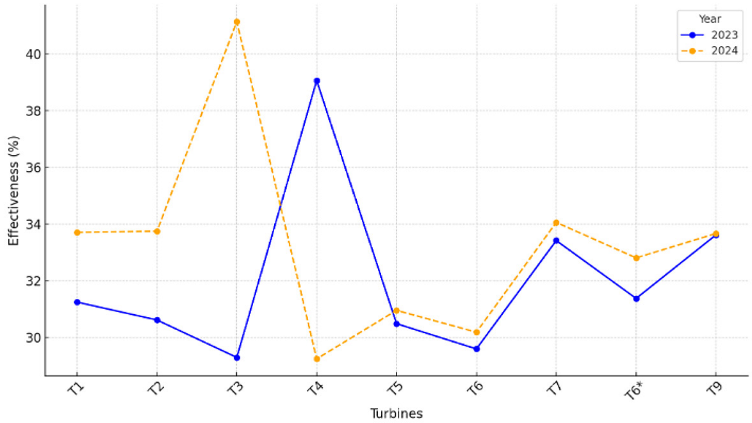

Figure 5. Comparison of the effectiveness of the turbines for the years 2023 and 2024

captured at higher speeds and, as a result, greater energy production. The tables provide wind speed data at five different height levels (80 m to 120 m) and an analytical simulation of wind speed at 80 m. The autumn months (September and October) have the highest wind speeds, with an average exceeding 8 m/s. This is typical of the autumn period, which often has more wind activity. The winter months (November and December) have the lowest speeds, with a noticeable drop, where the average wind speed for all elevation levels is lower than in other months. The wind speed (120 m) is always higher and the performance better, except in the winter months, when the difference is smaller. This confirms that the turbine located at higher altitudes is able to capture higher wind speeds and generate more energy. Wind speed (80) is always lowest at this height, indicating the importance of choosing a suitable height for maximizing turbine efficiency. When the wind speed is lower, the power generation capacity is also lower. Logarithmic simulation of wind speed (Log H5/80 m) gives an estimate of wind speed for other heights based on a mathematical model. This model provides an approximate result with real measurements and can be used to evaluate the performance of turbines at different heights. The annual average wind speed for all elevation levels is about 7.5 m/s for 120m and about 7.1 m/s for 80 m. This indicates that for lower altitudes, the wind speed is lower and will affect the performance of the turbines. From the data presented, wind turbine effectiveness varies between 2023 and 2024, showing significant changes in performance for most units: Turbines T1, T2, T3, T7 and T9 show a significant improvement in effectiveness in 2024 compared to 2023. In particular, turbine T3 experienced a large increase from 29.3% to 41.14%, suggesting successful technical interventions or conditions more favorable atmospheric conditions. Turbines T4 and T6 show a decrease in effectiveness from 2023 to 2024. For example, the effectiveness of turbine T4 drops from 39.06% to 29.25%. This may be the result of equipment degradation, insufficient maintenance, or unfavorable wind conditions. The T5 and T9 turbines exhibit stability with minimal variation between years, maintaining a consistent level of effectiveness. For example, the effectiveness of T5 is around 30.5%, while that of T9 remains almost constant at 33.6%. The use of Advanced Technologies with large power will improve the turbines that have lower performance and increase the total effectiveness of the park.

Based on the measurements we have made and the analyzes we have provided, several innovative aspects can be identified based on the following main points:

- increased turbine efficiency through advanced turbine design.
- the analysis of the impact of tower height (from 80 m to 110 m) on energy production is innovative because it shows how adjusting the height of wind turbines can have a direct impact on performance.
- the impact of wind turbine technologies on sustainable development and the environment emphasizes the importance of integrating renewable energy sources into the grid. By assessing environmental effects and ecosystem impact, the study is taking an innovative approach to balancing energy needs with ecological sustainability, ensuring that growth does not come at the expense of the environment.
- Technological Integration for Urban Development and Eco-Park.

CONCLUSIONS

The geographical infrastructure where the wind turbines are located in KITKA is suitable for the installation of new turbines in the upcoming period according to the planning dynamics. The study includes a comprehensive analysis of measurements for the efficiency of wind turbines and the generation performance value for the existing turbines. From the measurements taken, it was observed that a 3.6 MW generating turbine produces about 32% of the energy per year. To improve the generation efficiency of wind turbines, 4–6 MW capacity turbines should be installed for each individual generator, with 22 new turbines (22 × 6 MW = 132 MW) which would increase the efficiency to 66.7% per year. From the measurements made for the heights of the turbine towers from 80 m to 120 m in the annual period, it has resulted that the tower with the highest length generates energy with the highest performance. If we refer to the measurements of recent studies from the countries of the region, the generating performance of large turbines is an important factor in efficiency, naturally increasing the energy production capacity. The technology used for the turbines and turbine blades also plays a promising role in energy production, based on the availability of generation demands as a scenario for new turbines with a feasibility plan. An important part of the paper is the analysis of the impact on sustainable development, which includes the ecosystem's impact on the inhibiting effects of external factors. The implementation of new technologies and performance generation will also favor the inhibitive elements of urban integration. Considering the trends in sustainable development according to European directives for clean energy, the energy sector must follow the processes of innovative technological development. The impact on the eco-park includes the traffic infrastructure for the community living in the park's area. The strategic elements of the fundamental costs for determining the generation performance of wind turbines play an active role in the implementation of investment policies. In summary, innovative aspects based on these measurements include maximizing turbine efficiency through technological advances, optimizing turbine height and placement, and planning for sustainable development in harmony with environmental and societal needs. The integration of these factors demonstrates a comprehensive and forward-looking approach to wind energy production.

REFERENCES

1. Arnett E, May R. (2016). Mitigating wind energy ımpacts on wildlife: Approaches for multiple taxa. https://doi.org/10.26077/1jeg-7r13, 10
2. Chen Zh, Wang J, Guo Z, Dong Y, Yu J, Zhou RR and Xiao H. (2021). Statistical method of low efficiency wind turbine generating wind power curve based on operating data. https://doi.org/10.1088/1742-6596/2218/1/012062, 9.
3. Copping A, Gorton A, May R, Bennet F, DeGeorge E, Goncalves MR, Rumes B. (2020). Enabling renewable energy while protecting wildlife: An ecological risk-based approach to wind energy development using ecosystem-based management values. *Sustainability 12*(22), 9352. https://doi.org/10.3390/su12229352, 9.
4. Dusan M, Branko R and Zeljko D. (2006). Wind Energy Potential in the World and in Serbia and Facta Unıversıtatıs (NIS), 47–61.
5. European Commision. (2024). Energy, Climate change, Environment. https://commission.europa.eu/energy-climate-change-environment_en, 114–155.
6. Florescu A, Barabas S, Dobrescu T. (2019). Research on ıncreasing the performance of wind power plants for sustainable development. *Sustainability, 11*(5), 1266; https://doi.org/10.3390/su11051266, 10.
7. ICS. (2022). Integration Country Startegy. https://www.state.gov/wp-content/uploads/2022/05/ICS_EUR_Kosovo_Public.pdf, 3–18.
8. IHMK. (2022). Kosovo Hydrometeorological Yearbook 2022. Web: www.ihmkrks.net, 11(8), 1–46.
9. Maulana MI, Syuhada AA, Hasan A. (2024). Experimental Investigation of the Horizontal Axis Wind Turbine with NACA4418 Blade Length. https://doi.org/10.12911/22998993/191437, 272–281
10. MusyafaI A, Negara MY, Robandi. (2011). Design optimal in pitch-controlled variable-speed under rated wind speed WECS using fuzzy logic control. *Australian Journal of Basic and Applied Sciences*, 781–788.
11. Olabi AG, Obaideen K, Abdelkareem MA, AlMallahi MN, Shehata N, Alami AH, Mdallal A, Hassan AAM, Sayed ET. (2023). Wind energy contribution to the sustainable development goals: Case Study on London Array. https://doi.org/10.3390/su15054641, 15.
12. Osmani S, Hoxha B, Sekimaj R. (2018). An experimental study of Wind Data of a Wind Farm in Kosovo. *Przegląd Elektrotechnıczny, 1* https://doi.org/10.15199/48.2018.07.05), 4.
13. Radzka E, Rymuza K, Michalak A. (2019). Wind power as a renewable energy source. *J. Ecol. Eng, 20*(3), 167–171. https://doi.org/10.12911/22998993/99780, 167–171.
14. Rahman MM, Khan I, Field DI, Techato K, Alameh K. (2022). Powering agriculture: Present status, future potential, and challenges of renewable

energy applications. https://doi.org/10.1016/j.renene.2022.02.065, 731–749.

15. Rahman M, Ong Zh Ch, Chong WT, Julai S, Khoo Sh. (2015). Performance enhancement of wind turbine systems with vibration control: A review, https://doi.org/10.1016/j.rser.2015.05.078., 43–54.
16. Sankalpa KDCh, Herath HMDM, Wickramasingha KMSGMS, Samarakoon NGNB. (2024, April 05). Wind energy technologies: A complete review of the wind. *Journal of Research technology and Engineering, 5*(3), 178–204. June 22, 2024 tarihinde JRTE©2024 adresinden alındı
17. SE. (2012). *Energy Strategy of the Republic of Kosovo 2012–2022*. Ministry of Economic Development and Industry, 55–70.
18. Seaver W, Zeke H, Steven D, Juzel Ll, Erik B, Lauren L, Guido DN and Jameson M. (2023). Future demand for electricity generation materials. https://doi.org/10.1016/j.joule.2023.01.001, 11.
19. SERK. (2022). *Energy Strategy of the Republic of Kosovo 2020–2031*. Ministry of Economic Development and Industry, 16–44.
20. Shabalov M, Zhukovskiy YL, Buldysko A, Gil B, StarshayamV. (2021). The influence of technological changes in energy efficiency on the infrastructure deterioration in the energy sector. https://doi.org/10.1016/j.egyr.2021.05.001, 2664–2680.
21. Smith JD., and Miller B. (2021). *Reducing Wildlife Impacts of Wind Energy Development*. https://energy5.com/wind-turbines-and-wildlife-understanding-and-mitigating-environmental-impacts, 6.
22. Sofiu. V, Sofiu. M, Gashi. S. (2022). Solar radiation performance adjusting to PV system. https://doi.org/10.31202/ecjse.1121921, 1113–1121.
23. Suresh V. (2013). Physics of Wind Turbines/ http://digitalcommons.carleton.edu/pacp/7. Leipzig: Book.
24. Vehebi S. (2017). Wind turbine technology enables sustainable development of electricity in Kosovo. https://knowledgecenter.ubt-uni.net/conference/2017/all-events/135, 7.
25. Widuto A. (2023). Energy transition in the EU. European Parliamentary Research Service (EPRS), 10.