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Assessment of Wind Potential: The Case of Puka Region in Albania

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ABSTRACT

More than any time in the past, renewable energy sources and specifically wind energy are a focus point for research scientists as well as national governments across the world. However, the successful implementation of wind energy projects requires a thorough understanding, study and evaluation of the wind potential in the area of interest. This research work evaluates the wind potential in the region of Puka, Albania based on data from actual terrain measurements over 14 months, as well as measurements spanning 13 years from two atlases (Wind Balkan Atlas and New European Wind Atlas), analysed using the WasP program. Distribution maps of wind speed and power density at 50m a.g.l. show that hill summits in this area are classified as V and VI wind power class. The New European Wind Atlas was closer than the Wind Balkan Atlas to real-life terrain measurements based on the values of wind speed and power density gathered from the 9 wind turbines in the studied area. Observed wind climate files from both atlases show a 30^0 deviation in wind direction compared to terrain measurements. Changing the wind farm layout design for the turbines according to the main wind direction significantly lowered wake losses.

Keywords: Wind energy, Wind power class, WAsP, Balkan wind atlas, New European wind atlas.

1. INTRODUCTION

The entire global community is showing increased interest in renewable energy sources, especially wind energy [1]. This increased interest is partially a result of the current energy crisis caused by the war in Ukraine, and generally as part of the goals of reducing greenhouse gas emissions which have visibly affected climate change. Investing in renewable energy enables the creation of a sustainable energy system that is independent of imports, therefore strengthening energy security and lowering costs. Renewable energy sources are the lowest-cost source of new power generation for most countries in the world at [2]. In 2021 global cumulative wind power capacity reached 837 GW at [3].

Currently, Albania is a country completely dependent on hydropower for energy production. It is currently the country with the greatest share of renewables for power generation in the Balkans at [4]. However, due to the variability in hydric consistency, Albania is usually an importer for energy. Therefore, the diversification of energy sources is an important current objective of the Albanian government who is supporting these efforts also from a legislative perspective. The welcoming legislative context has prompted many investors, local and foreign, to apply for wind energy projects based on feed-in tariffs, participation in auctions or independently at [5, 6]. Most of these projects are currently in the feasibility stages of conducting terrain measurements of wind speed.

One of the main areas of interest for building a wind farm is the region of Puka located in northern Albania. The Albanian north is composed of a mountainous terrain and is considered to have high wind potential. This is evident in the wind map of mean annual wind speed distribution (m/s), measured at 10m a.g.l. as well as in the Wind Balkan Atlas (WBA) and New European Wind Atlas (NEWA) maps shown respectively in Figure 1, Figure 2 and Figure 3.

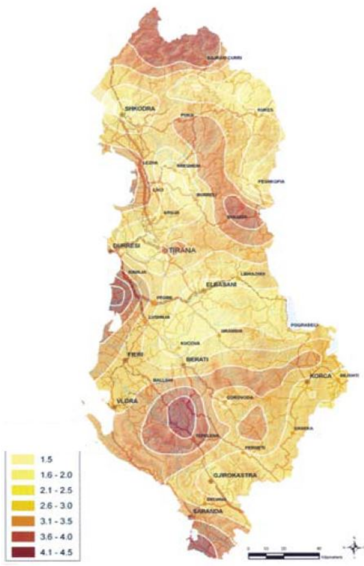


Figure 1. The wind map of mean annual wind speed distribution (m/s), measured in 10m a.g.l.

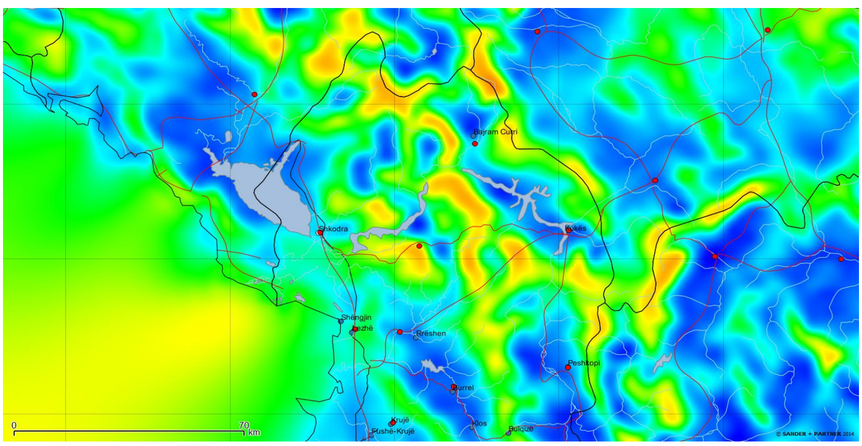


Figure 2. The map of wind speed distribution (m/s) at 50m a.g.l. in the Northern Albania provided by the Balkan Wind Atlas.

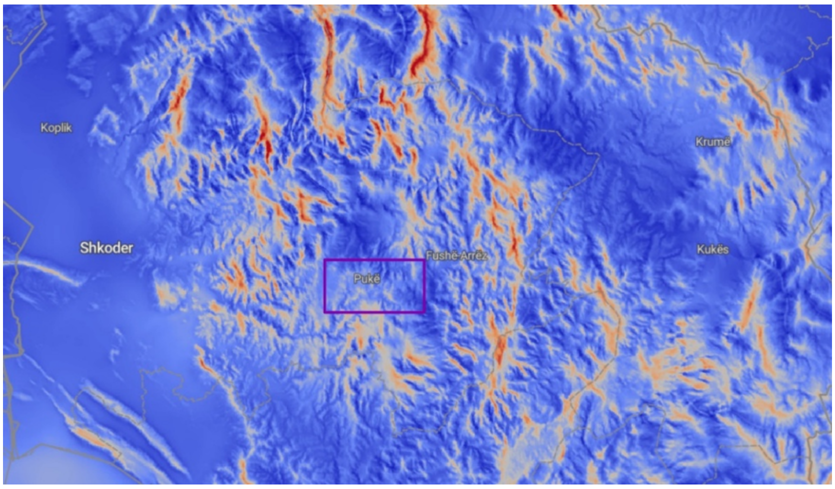


Figure 3. The map of wind speed distribution (m/s) at 50m a.g.l. in the Northern Albania provided by the New European Wind Atlas.

The evaluation of the wind potential in the region of Puka, Albania was carried out by comparing data from actual terrain measurements over 14 months (October 1, 2020 – November 22, 2021), with measurements spanning 13 years from two atlases (Wind Balkan Atlas and New European Wind Atlas), using the WAsP program. A similar study was performed by the authors in an area in the south of Albania.

Albania has historically lacked long term measurements of wind speed that have the standards necessary to build a wind farm. Therefore, utilizing wind atlases would help investors in feasibility studies for evaluating wind potential, and minimize costs of executing wind farm projects in Albania. Wind atlases are one of the primary tools of evaluating wind conditions and potential quickly, easily and reliably in an area of interest [7].

Global examples show that wind atlases have been used in many countries, not only to evaluate wind potential but also to support the construction of wind farms [8-11].

The goal of this study is to assess how reliable the data presented in the Wind Balkan Atlas and New European Wind Atlas is for areas of interest in Albania.

2. MATERIALS AND METHODS

One of the areas that has shown interest in setting up a wind farm in the north of Albania is located near the village of Kçirë, Puka region. The measurement campaign started on October 1, 2020 and lasted until November 22, 2021. The geographical position's coordinates of the actual measurements tower are latitude N 42.017773^0 and longitude E 19.824436^0. The time series data of wind speed, with length of time step 10 minutes, were acquaired through anemometers with 3 cone shape cups installed respectively at heights 20m, 40m, and 60m. The wind direction was measured through 3 wind vanes mounted at 20m, 45m, and 55m height.

The area under study is covered by rare trees. Wind data analysis tool Windographer was used to obtain vertical wind shear shown in Figure 4. It was found that the power law exponent by best curve fitting method is $a = 0.175$. Applying the logarithmic law of the wind shear profile, the roughness of the terrain around the anemometric tower was $z_o = 0.142m$, which corresponds to few trees' roughness description.

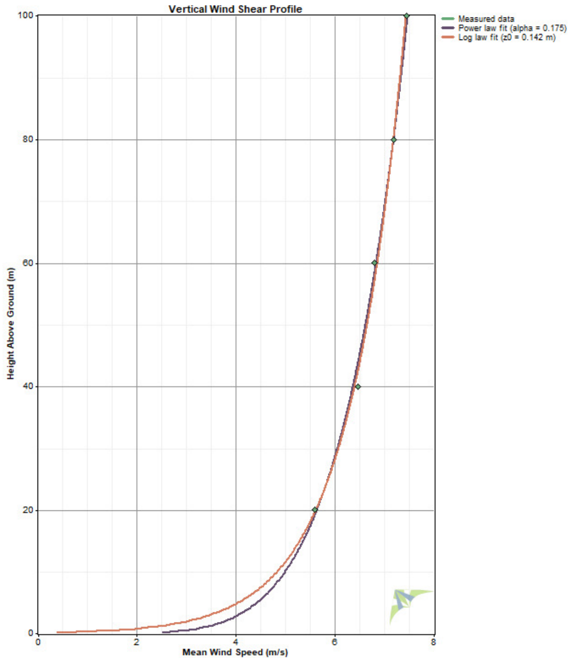


Figure 4. Vertical wind shear according to actual measurements

UTM coordinates of the anemometric towers from both atlases are given in Table 1.

Table 1. UTM coordinates of hypothetical anemometric atlas towers

Station	Latitude (m)	Longitude (m)	Altitude (m)
BWA	00402916E	04652240N	620
NEWA	00404178.9E	04649534N	577

The relative positions of the atlas towers and the actual measurements are shown in Figure 5.

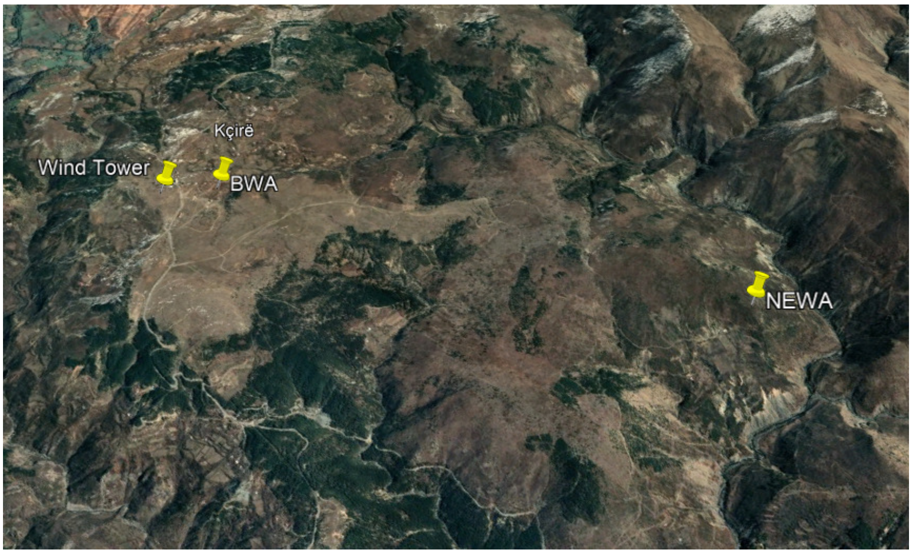
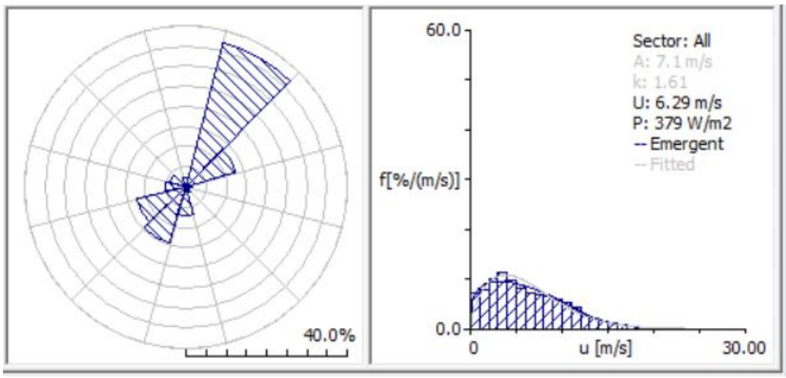


Figure 5. Mutual position of anemometric towers from both WBA and NEWA, with the actual measurements tower in Kçirë, Puka region

Both atlases are missing data for the wind speed during the time period of the field measurements. As a result of this, the study used atlas data from the last 13 years BWA

(2000 – 2013) and NEWA (2005 – 2018) for the estimation of the wind potential for this area.

WAsP program was used to visualize the wind patterns by actual measurements as well as by both of atlases obtaining Observed Wind Climate (OWC) files for each tower at 50 m above ground level. In Figure 6 are shown the wind rose charts and Weibull propability distributions according to the WAsP OWC files for each tower.



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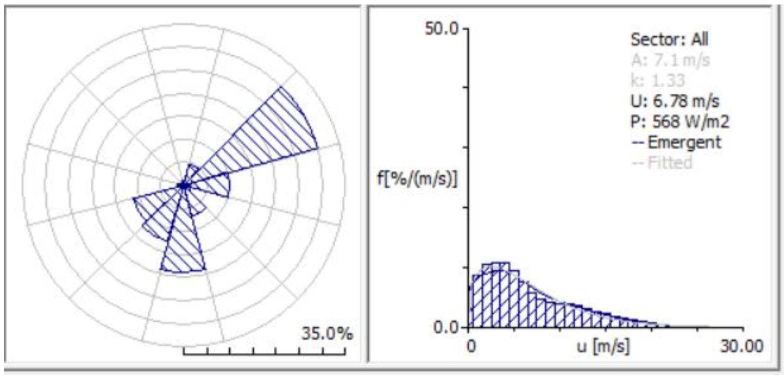

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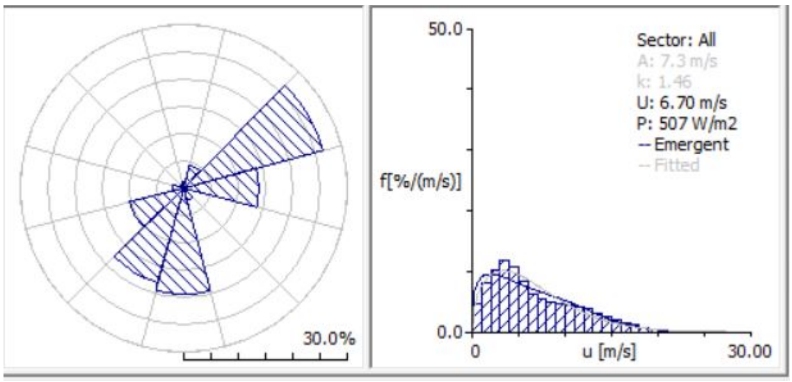


(c)

Figure 6. Wind rose charts and Weibull probability distribution for Kçira, Puka region at 50 m above ground level.

According to the two atlases, the frequencies of the distribution of wind direction in the area differ slightly. The main direction of wind based on the two atlases is North-South. This direction has a 30^0 deviation when compared to the empirical measurements of wind speed in the area. Whereas, the average speed and wind power density according to the WBA observed wind climate file vary slightly by being 0.8 m/s and 61

W/m^2 higher respectively when compared to those from NEWA observed wind climate file. But wind speed, power density and *A* and *k* parameters of the Weibull distribution function recorded from NEWA tower are closer to the actual measurements in Puka region.

Figure 7 shows the seasonal variation of the average monthly wind speed in the area based on the three anemometric towers.

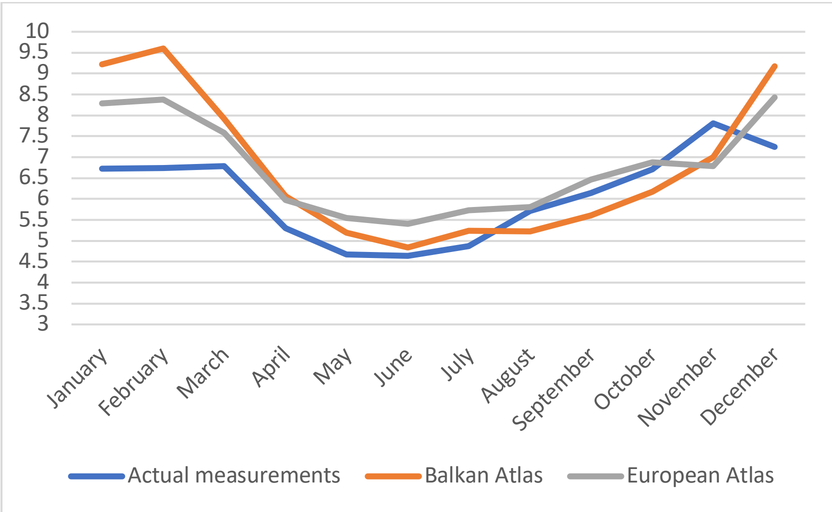
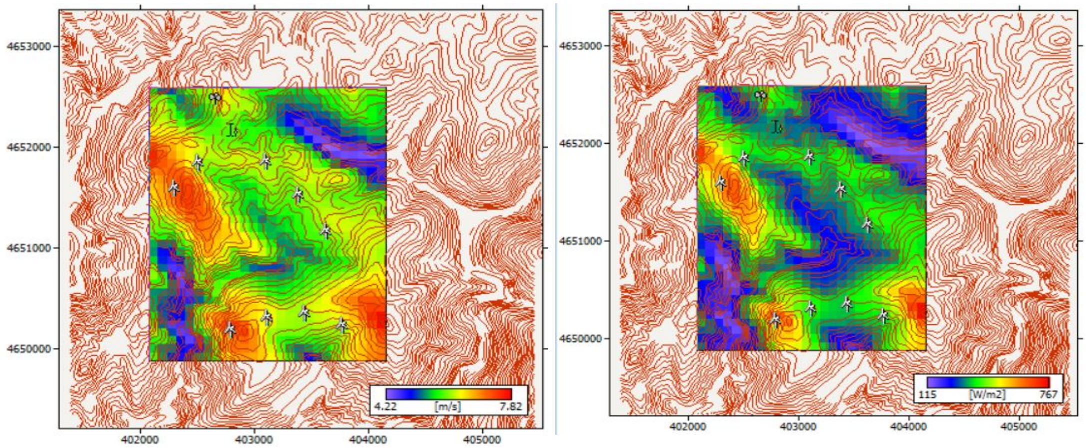


Figure 7. Mean monthly wind speeds according to actual measurements, BWA and NEWA

Wind speed in Albania is lowest during the summer and highest in autumn and winter, until the month of April. This figure also shows that the differences between the speed values from real measurements and the European Atlas are smaller than the Balkan Atlas.

The maps of wind potential distribution at 50m elevation a.g.l. in the Kçirë area of Pukë were plotted with the WAsP software. Figure 8 shows wind speed and power density distribution maps developed on the basis of OWC files from actual measurements, as well as from both atlases' towers. The area has 3 hilltops with the highest wind potential.

The preliminary project in this area suggests the development of a wind farm with 9 wind turbines with a total power up to 30 MW.



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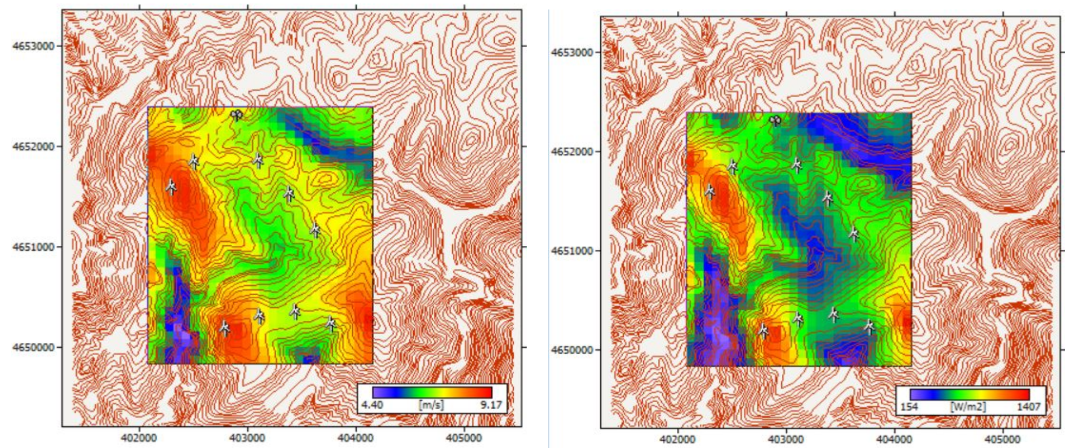

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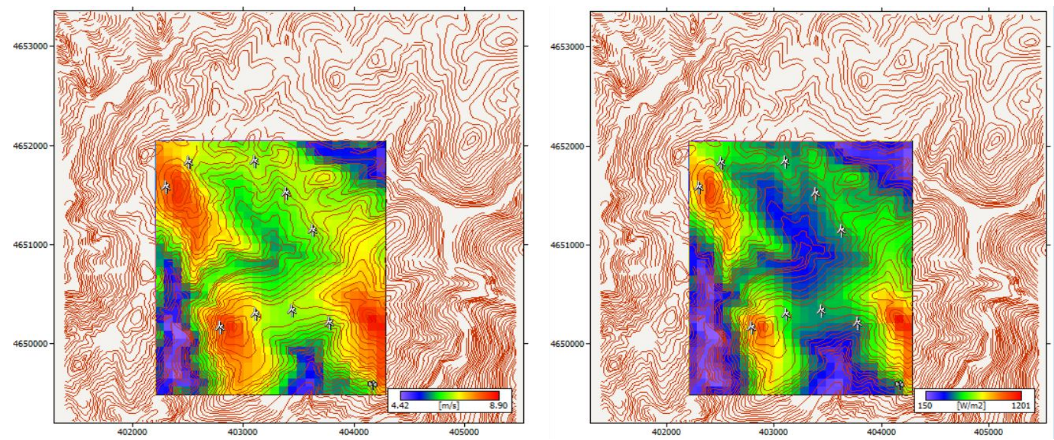

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Figure 8. Resource grid of wind speed and power distribution at 50 m a.g.l. at the Puka site according to the: a) Actual measurements, b) WBA tower, and c) NEWA tower

This study has considered a wind turbine with hub height of 50 m. Figure 9 depict the wind speed at the hub height for each wind turbine according to wind speed distribution maps from the 3 towers in site.

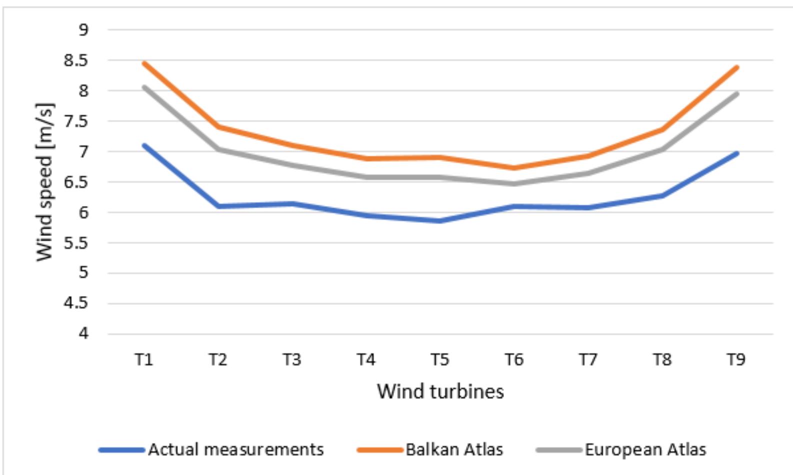

Figure 9. Wind speed at the wind turbines hub height according wind potential maps of actual measurements, BWA and NEWA.

The almost parallel lines of the wind speed at 50m a.g.l. elevation plotted according to resource grids from WBA and NEWA show that the data from these atlases are comparable. Both atlases overestimate the wind potential parameters. However, NEWA data are more similar to the real measurements.

According to wind speed and power density distribution maps developed by WAsP software, the hilltops establish territories with class V wind power, making the area in the study very attractive for the utilization of wind energy.

Changing the wind farm layout design for the turbines according to the best wind potential terrain and the main wind direction as it is shown in Figure 10, significantly lowered wake losses.

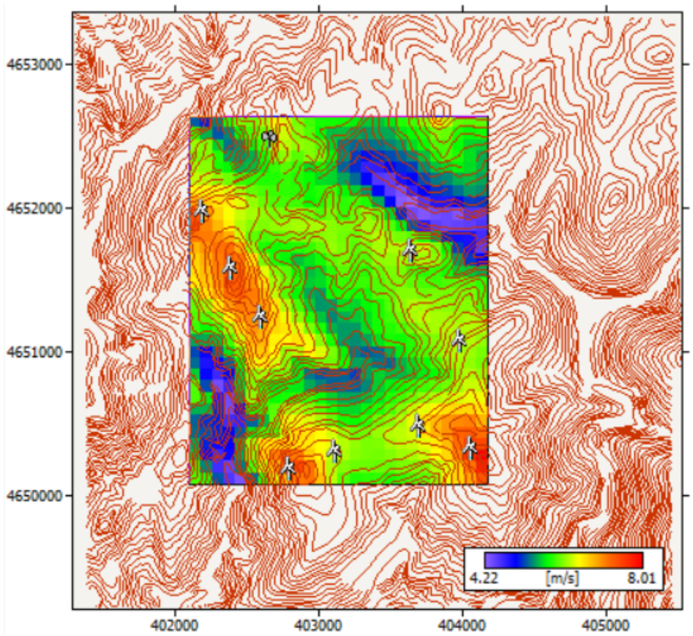

Figure 10. New wind farm layout design in Puka region.

The new wind farm layout design has shown the reduction of wake losses with 47%. This reduction in losses increased the electricity production forecast by 15%.

3. CONCLUSION

In this research work is shown the evaluation of the wind energy potential for the Kçire area of Puka region. The study used data from real measurements in the field over a period of 14 months, as well as long term data over 13 years from two hypothetical anemometric towers found in WBA and NEWA. Data comparison in the study showed that the two atlases are comparable models. NEWA data are closer to the real measurement data in the field because they have smaller overestimation of wind speed and power density when compared with data from WBA. Based on these findings, we believe that using atlases in the Albanian context, where long-term data are sparse, will be an efficient tool to inform the preliminary steps of planning the development of wind farms for Albanian investors.

Based on wind speed and power density the study area is evaluated as class V and IV of wind power suitable for the development of wind energy projects. Our future work will focus on investigating other areas with high wind potential in Northern Albania.

CONFLICT OF INTERESTS

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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