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Solving the Bottleneck Issue of Energy Supply. Case Study of a Wind Power Plant

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ABSTRACT

This paper addresses the current need for increased renewable energy capacity in the southern region of Albania near the tourist destination of Vlora. The northern half of the country is burdened with supplying the electrical needs of the country, while the southern region is using the electricity at high rates during summer months. Freely available wind energy resources, along with a wind siting study of the country which has already been performed, are used to locate, and analyze potential wind farm sites near Vlora. Less than 40 km southeast of Vlora a site is identified, and a techno-economic assessment and site performance simulation is performed using RETScreen wind energy software. The results show that this site is feasible, and a windfarm is proposed which is capable of exporting 243.4 GWh to southern Albania's electrical grid yearly. With a short equity payback period of 5.6 years and simple payback of 9.7 years, this location could deliver substantial amounts of energy where it is needed, without worry of transmission losses over large distances.

Keywords: Renewable energy, wind power, energy supply, RETScreen.

1. INTRODUCTION

In seeking to diversify in energy generation, Albania has recently shown interest in scaling up their efforts in renewable energy outside of hydropower. Wind, solar, and geo-thermal sources are three of the most likely candidates for future power contributions as they are receiving attention from governmental agencies [1]. The Albanian Ministry for Infrastructure and Energy (MIE) is running the countries first tender for utility-scale onshore wind power plants with support from the European Bank for Reconstruction and Development. Submissions for individual projects with capacity of between 10 MW and 75 MW are due by mid-June 2022 with selections to be made in early 2023. Out of the successful projects selected, the expected total capacity will be 100 MW with the potential to increase to 150 MW [2].

A wind siting study has been commissioned by and submitted to the MIE, which is available to potential bidders of this tender to assist in shortening the process time of bids. This study evaluated the entire Albanian territory to assess suitable areas for the development of wind power plants. The output map from the report shows areas designated as "no-go areas" such as near historical landmarks, proximity to airports, critical habitats, and other protected areas. Through a ranking system based on environmental, social, and technical indicators the wind siting study produces a map displaying areas of high and low suitability for a wind farm, as well as the no-go areas mentioned previously. The highest scoring 20% of available land corresponds to a total area of 350,000 hectares with a suitability value greater than 70% [3].

The benefits of wind energy are well cited, however the location for the wind farm can have serious negative environmental effects on an area, especially concerning animal populations. Collision fatalities of bats and birds is a major problem concerning wind turbines. Using adjusted fatality rate data from publicly available studies, estimates of average cumulative annual bird fatalities in the continental U.S. published in 2013 and 2014 ranged from approximately 230,000 to 600,000 birds per year and 200,000 to 800,000 bats per year [4]. Ultrasonic deterrent systems for bats [5] and acoustic deterrent systems for birds [6] have been developed and found to be successful in reducing the collision hazards with tall manmade structures such as wind turbines. This may mitigate some future problems associated with wind farm locations and their hazards to aerial animal populations.

While Albania is yet to have serious investment in wind energy, in other regions which have, societal acceptance has been an important factor for the success of a proposed wind farm location. Commonly cited public aversions to wind farms are related to the noise which they generate, and the perceived negative visual impact that they have on the surrounding landscape. Researchers in Germany [7] have arranged a study to find what factors are most influencing their citizen's acceptance of wind farm locations. It was found that people who have already had experience with wind turbines have a more positive outlook on wind energy, and that the distance between the turbines and their place of residence has no influence on their approval of wind energy. The fear of infrasound was found to have the most significant negative influence on wind energy acceptance. In North America it is found that proximity of residents to wind turbine location is unclear from a purely visual and sound annoyance standpoint. The socioeconomic factor is considered a stronger influence, as residents would like the benefits of the wind farm to be enjoyed locally and may feel a sense of injustice for bearing the burden of the wind farm if the profits and energy are consumed elsewhere [8].

Albania is made up of 70% mountainous terrain with an average altitude of 708 m throughout the country [9]. Mountain ridges are known for having high wind speeds though elevated and rough terrains can create technical problems for wind farm instillations and maintenance. Wind energy over complex terrains is an active research area still in its infancy and there is need for new experiments and high-quality simulations of wind farms placed over complex terrains in order to develop new simplified models and knowledge to design future wind farms [10]. If properly exploited, and the economics and logistics are sound, the benefits of building wind farms at higher elevations can reduce the capacity that is required to produce large amounts of wind power [11].

Regarding Albania, the terrain is very tough with high mountains. Vlora is chosen as an important location for considerations for several reasons: balance of electricity system of Albania, new strategic investments, tourism, windy areas etc. The following sections will analyze these factors.

2. ENERGY USAGE

2.1 Balance of Electricity System of Albania

The main power supply in Albania is from hydro resources, hence the electricity production is seasonally dependent, means that during the dry seasons the country will not fulfill the energy demand. Integration of other renewable sources as wind energy will diversify the sources of power supply, hence produced electricity will remain constant even during dry periods [12]. Installed capacity of electricity in Albania in 2019 was 2162 MW from hydropower. Meantime, the installed capacity in Drin cascade located in the northern part of Albania is 1400 MW. Soon Skavica hydropower plant will be built in this cascade, and this will increase the power capacity of the Drin cascade with an additional 250 MW installed power, bringing the total to 1650 MW. The over-all capacity installed in Albania, including Skavica hydropower, will be 2412 MW. This means that 67% of electricity power plants will be installed in northern part of Albania [13]. That indicates that the electricity system in Albania is not currently balanced. Furthermore, the population density, as can be seen from the demographic data, shows that the middle and southern regions are more populated. So, for all of these regions to fulfill the energy requirements, electricity have to be transmitted from northern part of the country. As can be seen in Figure 1, the grid electricity losses in 2020 have been 22% or 1.63 TWh of the total electricity used in Albania.

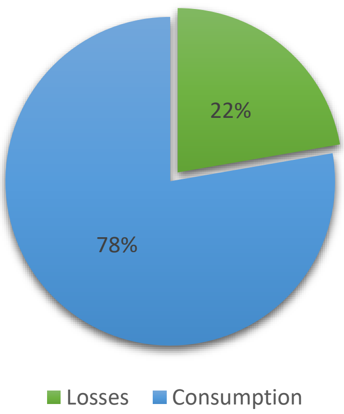

Figure 1. Electrical loss in Albania

Only 5.69 TWh was able to be used from 7.32 TWh which was generated [14]. So, to balance the electricity system in Albania new power plants will have to be built in southern part of the country. To be in line with the EU policy these will have to be from renewable sources.

2.2 New Strategic Investments

Referring to government policies in Vlora, Albania, a new airport will be built, as shown in Figure 2. The construction planned to begin on 28 November 2020. This will be a 4E category airport and will be the biggest airport in Albania, which is designed to accommodate all flights to and from anywhere in the world. Also, there will be additional space allocated to perform airplane maintenance. Further, can be used as a transit. The reason that this is seen as an important factor is because this airport will demand high amounts of electricity. To cover this demand there will be a need for additional electrical capacity in the region. The airport is predicted to indicate in the economy of the city as well as in Albania. This means that the demand for energy will not only be increased because there is a new airport, but also because of the number of tourists that will be increased in this area, due to this investment [15].

Figure 1. Vlora airport proposed layout [14].

2.3 Tourism in Vlora

Albania has low energy consumption per capita, which reveals low economic activity and modest level of comfort [16]. However, visitors to the region will bring with them an increase in energy demands for accommodation and leisure activities. The total numbers for nature tourism in Albania during 2019 has been 4 565 449 tourists [17], as can be seen in Figure 3. 18% of tourist have been in Vlora and 18% in Fier. These cities are located in the southern region and covers 36% of Albania nature tourism, and with the construction of a new airport the number of tourists will be increased. So, this is another contributing factor which shows there is an immediate need for a new renewable power plant.

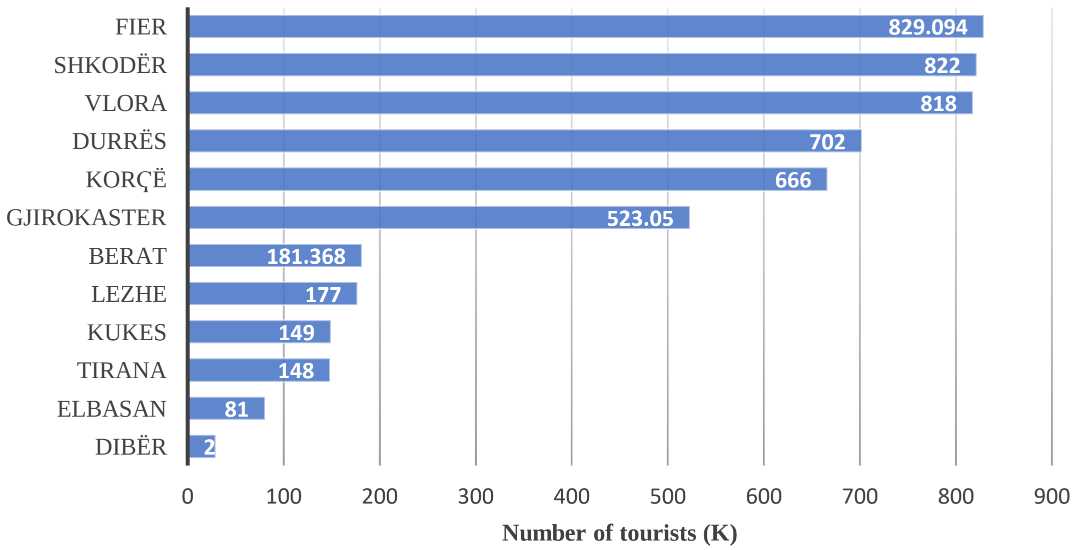

Figure 3. Nature tourism in Albania 2019.

3. MATERIALS AND METHODS

3.1 Energy Tools and Resources

A combination of tools is used to locate suitable areas, within adequate proximity to Vlora, to examine the potential and feasibility of a wind farm project. The wind siting study, presented to the Albanian MIE in 2020, is the preliminary source of information for this analysis. The suitability maps provided within this study, seen in Figure 4, are intended to assist potential developers and streamline the site selection process for this tender. Areas in which there is good tradeoff between Albania's sustainability goals and potential for energy production are highlighted in a deep green color. Areas which may look like a strong fit for a wind farm from a technical standpoint may be protected by the government as critical habitat, have unusually high bird activity, or risk of geohazards. This is only the starting point, as a more in-depth analysis is needed to bring conclusions for the specific region and goal of renewable energy near Vlora.

The information in the suitability study is used in tandem with Global Wind Atlas [18]. This is a free, web-based application developed to help policymakers, planners, and investors identify high-wind areas for wind power generation and perform preliminary calculations. The high suitability areas from the wind siting study are investigated further with the use of an interactive, color schemed map, shown in Figure 5, showing mean wind speed data. The user is able to draw an outline on the map, representing the size and location of a potential site, and receive wind data about the area. This includes information about average wind speed and direction well as annual, monthly, and hourly wind speed variability at a specified high above the landscape. This application can also receive wind turbine information for energy yield calculations.

However, for this paper the data from Global Wind Atlas will be input into RETScreen wind energy software for estimations regarding cost, power generation, and environmental factors.

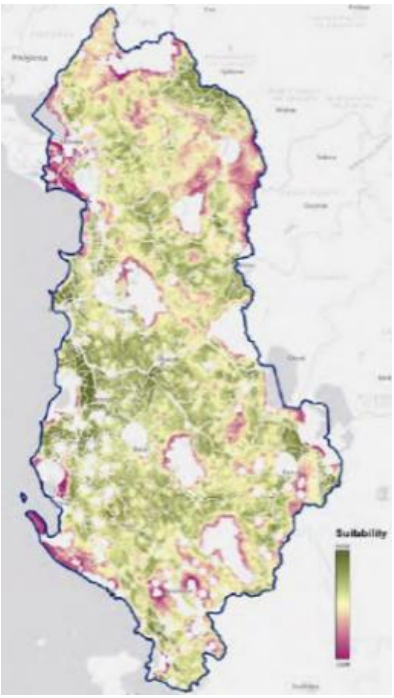

Figure 4. Suitability map [3].

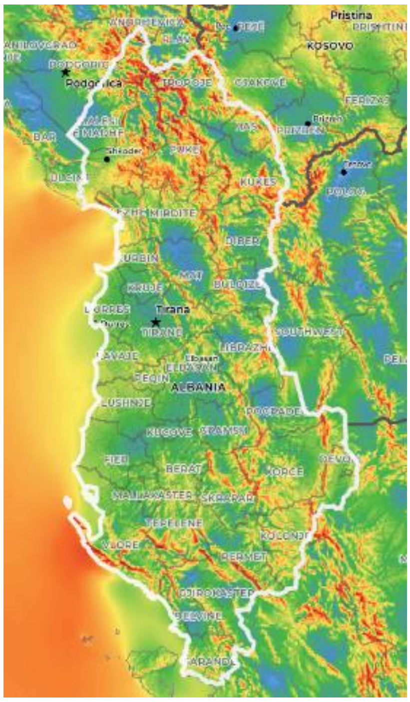

Figure 5. Wind speed map [16].

3.2 Identifying Potential Locations

Along with the metrics covered in the wind siting study, this paper aims to focus the search to areas around the city of Vlora. Using the Global Wind Atlas [18], a search is conducted in a radius of 50 km around the city. A filter is applied to identify areas with mean annual wind speed of 6 m/s or higher, as can be seen in Figure 6. The summer months in southern Albania can experience decreases of 40% from the average wind speed, so this value is chosen to account for the low end of those variations.

In this proximity to Vlora, the majority of areas with the required wind speed are at high elevation, near the ridges of mountains. There are no areas to the north of Vlora which fit the criteria. To the southwest of the city is mostly protected area, or critical habitat. To the southeast there are a number of sites which match the initial search criteria.

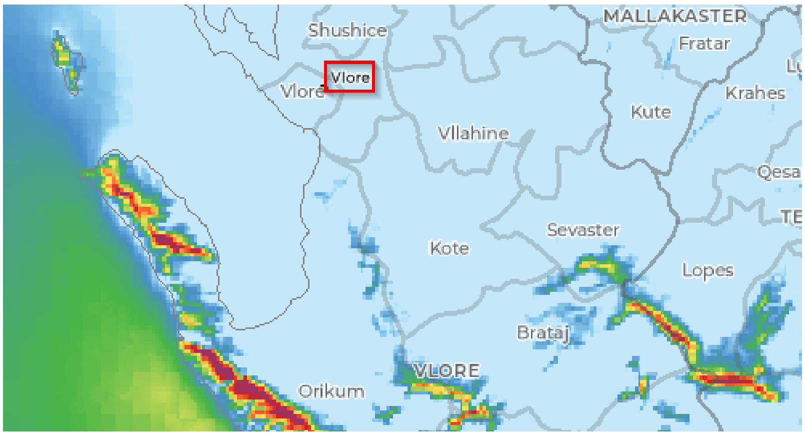

Figure 6. Wind map near Vlora [16].

3.3 Preliminary Data Collection

While investigating the regions which meet the criteria, the Global Wind Atlas pro-vides the average annual wind speed along with a Wind Speed Index value for monthly and hourly variability. The RETScreen software is only able to access weather data from the weather stations which exist in its database, so the site-specific wind data are retrieved from Global Wind Atlas and entered into the software manually. RETScreen uses the monthly average wind speed data to estimate the electricity the site is able to export to the grid monthly and in turn yearly.

The wind's speed constantly varies, so a probability distribution of the range of wind speeds is necessary to predict the power generation capabilities of a wind turbine. In the field of wind energy, the Weibull Distribution is a commonly used and reliable function. To find the Weibull Distribution for the potential sites, the monthly and hourly Wind Speed Index is used to calculate the frequency percentage in which the wind is at each speed range in 1 m/s increments. This data is entered into the Weibull Calculator tool available from The Swiss Wind Power Data. This outputs a histogram of the frequencies, along with a shape factor value and scale parameter for use in RETScreen.

3.4 Main technical parameters

3.4.1 Wind Speed Distribution

Wind speed distributions shows the distributions of wind speeds during the year on the sites. Weibull distributions is one of the wind speed distribution methods that is widely used because includes a wide range of wind frequency distribution [19].

The Weibull distribution for wind speed V, is expressed by probability density function**,** "Eq. (1)".

$$f\ (v) = \frac{k}{A}(\frac{v}{A})^{k-1}\exp(-\left(\frac{v}{A}\right)^{k}\Big) \qquad (1)$$

where A- is the Weibull scale parameter in m/s, a measure for the characteristic wind speed of the distribution, A is proportional to the mean wind speed [20], k - is the Weibull form parameter. It specifies the shape of a Weibull distribution and takes on a value of between 1 and 3. A small value for k signifies very variable winds, while constant winds are characterized by a larger k [20].

From this theory can be predicted how much energy can be produced for each individual turbine placement, but in this case, it will be done as an average for the selected area. So, to have a real prediction of how much energy will be produced from wind turbines in a year, it needs to be known how strongly and how often the wind blows in a fraction of time. Usually, the measurements are done once every 10 min to have a real prediction. This data can be sorted into wind speed classes of 1 m/s each [20].

3.4.2 Energy Curve

Shows the total energy produced by a wind turbine from average wind speeds during a year, using wind speed increments 1m/s, which starts from 0 m/s to 25 m/s (cut off) wind speeds, "Eq. (2)", [21]

$$E_{\bar{V}} = 8760 \sum_{x=0}^{25} P_x\, p(x) \qquad (2)$$

$\bar{V}$- shows the wind speed used in equation
P_x- is the power of turbine at **x** wind speed
$p(x)$- is the power of turbine at **x** wind speed

3.4.3 Capacity Factor

Capacity factor of a wind power plant is the ratio of energy produced in a year over the maximum energy that this power plant can produce over a year, "Eq. (3)"**,** [22].

$$PFC = \left(\frac{E_C}{WPC\ \ h_Y}\right)100 \qquad (3)$$

E_C- Energy produced for a year by power plant (kWh)
WPC- Installed power capacity of the plant (kW)
h_Y- Hours of numbers in a year

4. RESULTS

The search parameters produce four areas which are sizable enough to host a wind farm of between 10MW and 75MW, shown in Figure 7. Of the four regions, 3 of them are in areas which are protected or have shortcomings related to wildlife and natural habitats. If not for these restrictions, areas 1-3 would be highly suitable for a wind farm because the high terrain in the areas and proximity to the coast produce high average annual winds. The following section summarizes these areas.

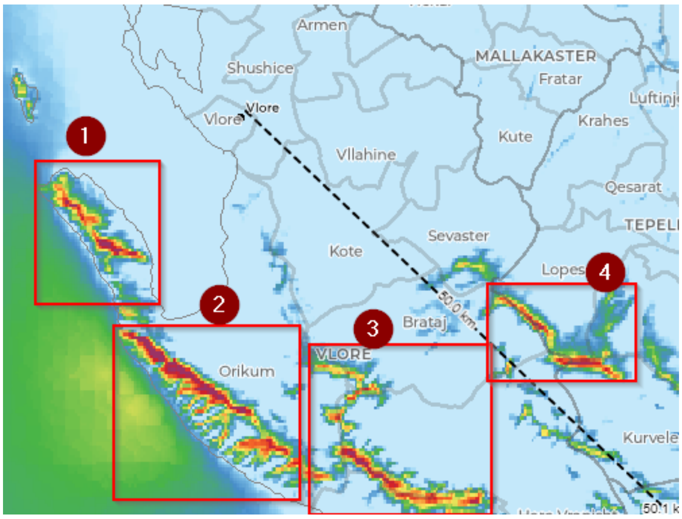

Figure 7. High wind regions [16].

4.1 Evaluated Areas

The provided wind siting study gives Area 1 a suitability rating of 1 out of 5. This is because there are a large number of birds around this location as well as other critical habitats. This area is also shown as having a high probability of geohazards. From a technical standpoint there is limited access by road, though the infrastructure would need to be expanded to support a large wind farm project. Even though it is rough and elevated terrain and not all of it will be suitable to build upon, there is still usable land large enough to support a wind farm with 34.4 km² total. The average annual wind speed here is 10.21 m/s, and Global Wind Atlas shows it as having a mean power density of 1616 W/m².

In the wind siting study, Area 2 is given a mixed rating of low and medium/low, or between 1-2 out of 5. While it is not in a "no-go" area, it also is restricted by a large number of birds and critical habitats along the coastline. This area is also at an elevated risk of geohazards. Area 2 scores slightly higher over Area 1 because there is a major road running nearby which will make transporting components much easier. It is also a larger area at 77.6km² with slightly higher average annual wind speeds at 10.83 m/s which produce a mean power density of 2112 W/m².

Area 3 is similarly given a suitability rating mix of low and low/medium, or between 1-2 out of 5 rating. This area borders a "no-go" zone but is not within it. It also takes a low rating because of a large number of birds and is very close to historical resources in which the area is protected. The area also benefits from a major road which runs down the coast nearby. This is another large area of high wind, which could easily support a wind farm of between 10MW and 75MW with a total available surface area of 84.3 km². Area 3 produces the lowest average annual wind speed of the three areas at 9.9 m/s, but this is still more than enough wind for adequate power production. The mean power density here, according to Global Wind Atlas, is 1649 W/m².

4.2 RETScreen Simulation

After analyzing the climate data, terrain, and protected areas, the most suitable location is Area 4 located at 41.33N and 19.83E. This area has good climate data, suitable terrain, and is not classified as a protected area. Area 4 is approximately 50 km^2, and referring to the tender, will have to support from 10MW to 75 MW installed capacity. The average required area for a 2MW wind turbine is 0.5 km^2 [23], so this site can easily fit 37 turbines which means that the total power capacity will be 74 MW. RETScreen software is used to simulate this area, to see how much energy can be produced, in manner to provide a clear view and a strongly based argument. In Table 1, the average climate data for this area is shown.

Table 1. Climate data for Area 4 (measured at 100m) [16].

Months	Wind speed (m/s)	Atmospheric pressure (kPa)	Air temperature (°C)
January	11.0	101.1	11.1
February	12.4	100.9	10.9
March	14.3	100.8	12.3
April	9.6	100.6	14.6
May	7.2	100.7	18.3
June	6.1	100.7	22.0
July	5.2	100.6	24.7
August	5.3	100.6	25.3
September	5.7	100.8	22.6
October	8.9	101.0	19.4
November	11.3	101.0	15.8
December	12.9	101.0	12.4
Annual	9.2	100.8	17.5

The source for this climate data, as mentioned previously, is from Global Wind Atlas. The wind climate data are measured at 100 m elevation above the ground. The annually average wind speed for this area is 9.2 m/s and the maximum and minimum monthly average temperature data varies from 10.9°C to 25.3°C. This means that the climate conditions for the turbines are suitable and there are not going to be marginal costs due to frozen or hot air, which directly indicates the efficiency of wind turbines being high. As can also be seen in Table 1, the windiest months are from October to April while the summer months are less windy. The average wind speed in July, which is a less windy month, is 5.2 m/s. If the cut in speed for the turbines starts from 4 m/s and higher, that means that this month the wind turbines will still produce electricity.

Next step of the simulation, after the determination of the area, is to select the proper wind turbine for the climate and terrain data given. Important criteria include turbine's power rating, height of tower, energy output, rotor diameter, cut-in wind speed, and rated wind speed, from (Fuzzy Logic Based Multi Criteria Wind Turbine Selection Strategy). The first criteria that was considered was hub height. The wind speed measurements are based on 100 m above the ground, so a suitable hub height will be a height that varies from +95 to +105 m from the ground. The second criteria are the rated wind speed of turbine. If the average hourly climate data for one year is analyzed, it can be seen that there is no data for wind speed lower than 4 m/s. It starts at 4-5 m/s with a frequency of 4.86% and ends at 15-16 m/s with a frequency 2.78% and above this speed there are no further data. The third criteria considered is cut-in wind speed. As mentioned previously, the minimum average hourly wind speed for a year starts at 4 m/s and from 4-5 m/s has a frequency 4.86%. So, the cut in wind speed is at 4 m/s. Regarding the first three criteria, as the fourth main criteria, the turbine's power rating is chosen. The installed power for one turbine is determined by wind speed, height of hub, cut in speed and terrain surface. So, the turbine that is chosen is a Vesta V90 2MW- 105 m. This turbine has a rotor diameter of 90 m, power capacity of 2MW, and hub height at 105 m, as can be seen in Table 2. This selection is done due to above criteria selection. This turbine has a rotor diameter of 90 m, power capacity of 2MW, and hub height at 105 m [24]. This selection is done due to above criteria selection.

Table 2. Wind turbine selection [22, 29].

Wind turbine	Selection
Power capacity per turbine (MW)	2
Manufacturer	Vesta
Model	V90-1.8/2.0MW-105m
Number of turbines	37
Power capacity (MW)	74
Hub height (m)	105
Rotor diameter per turbine (m)	90
Swept area per turbine (m^2)	6 362
Shape factor	3

A wind farm generating electricity with 37 Vesta V90-2 MW-105 m turbines, with an overall power capacity 74 MW, can produce max 648.6 GWh electricity if they work all throughout the year at their highest efficiency. However, there are factors involved that will not allow this, which will be explained below. First factor is wind speeds distribution.

In this case the Weibull distribution is shown in Figure 8. The shape factor is defined as k=3 from Swiss Wind Power Data [20]. As it is showed, the mean value of wind speed from graphic is 9.16 m/s, and the Weibull scale parameter A= 10.46 m/s. In the RETScreen simulation a shape factor of k=3 is used, this was determined by the Weibull distribution function "Eq. (1)" for the selected area.

Each wind turbine has its own characteristic power curve data, which is comprised of their cut-in speed, how much energy they produce in different wind speeds, and cut out speed. For Vestas V90 2MW- 105 m, the cut-in is at 4 m/s wind speed, and in this wind speed the turbine power capacity is 93.3 KW. At wind speed of 4 m/s the speed frequency distribution for this area is 4.86 % and for 1 Vesta turbine installed, there will be 1242 MWh/year produced. So, for shape factor k=3, how much energy will be produced in different wind speeds for the V90 wind turbine is shown in Figure 9 [24]. From this data is possible to build the Power and Energy graphics for different wind speeds, as is shown in Figure 9. There are two graphic lines displayed. The blue line is the power curve which is the characteristic of Vesta V90 2MW- 105 m wind turbine. In this line it can be seen where the cut-in speed is, for which wind speeds it produces more power, and the cut-out speed. While the red line represents the energy produced from Vesta V90 2MW- 105 m wind turbine, with a shape factor k = 3 for different winds speed.

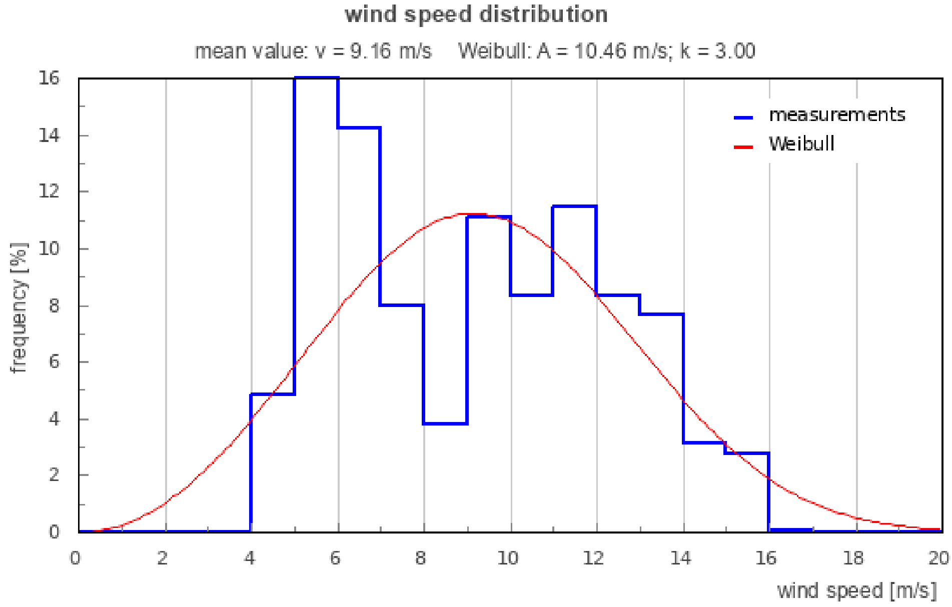

Figure 8. Weibull distribution

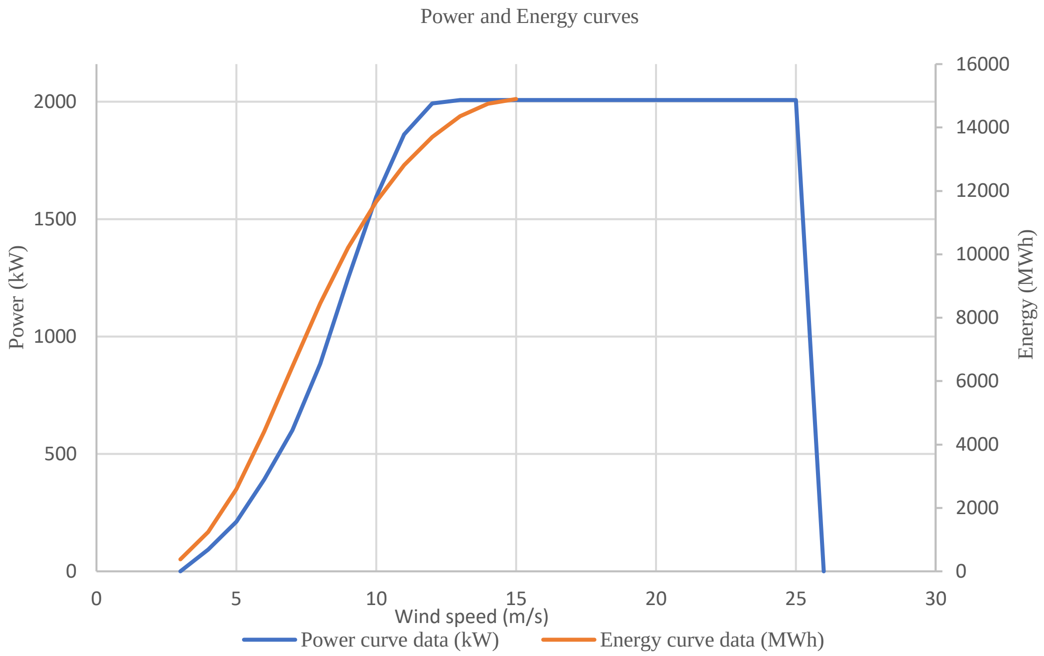

Figure 9. Power curve for Vestas V90 2 MW - 105 m

An important part of the simulation is the estimation of losses. In a wind farm there are several types of losses, but this paper will go into the details of only four of them. These are losses from array, airfoil, miscellaneous and availability, shown in Table 3. Array losses are the average estimated losses (%) from all wind turbines arrayed in a wind farm. These are caused by the interaction of multiple wind turbines with each other through their wakes. Turbines in the "shadow" of others do not "see" as much wind as the front ones and energy production is decreased as a result. Array losses is depended on the turbine spacing, orientation, site characteristics and topography. Typical values for a well-designed wind farm range from 0 to 20% of "Gross energy production". The lower end of the range corresponds to small clusters of well-spaced turbines while the higher end of the range corresponds to a closely packed wind farm with a weak dominant wind. Array losses for a single turbine installation are 0% and it increases with the increments of wind turbines [21].

Table 3. Losses associated with wind farm [19].

Losses	Selection
Array losses (%)	10
Airfoil losses (%)	7
Miscellaneous losses (%)	6
Availability (%)	90

In this case is decided to take the maximal losses 10%, because the area it’s enough big and the turbines will not indicate that much each-other. Airfoil losses are losses that are caused from the impurities or ice that are accumulated on the blade surface during the rotation. Impurities may be bugs or dust that affect the aerodynamic performance of the blades. Usually, those losses vary from 1 to 10%. In this case it is decided to take a loss of 7% because of the presence of bugs, birds, and dust in this area, but also to include the worst scenario because this study it not based on terrain measurements but from literature. Miscellaneous losses represent losses of energy production due to starts and stops, off-yaw operation, high speed winds, and cut-outs from wind gusts. Also, is included any parasitic power requirements and any transmission line losses from the wind energy project site to the point where the project connects to the local distribution grid. Typical values range from 2 to 6% of "Gross energy production" [21]. In this case the worst scenario was taken at 6% miscellaneous losses. Availability means that from all the wind turbines that are in a wind farm, how many hours they have worked due to wind turbine brakes, maintenance, or system failure. This factor is also escalated because of the terrain. Availability of a turbine varies from 93 to 98%. Due to the turbines, in this case, being located on a mountain site, it will take more time than usually for maintenance or repair of wind turbines, and also the parts of wind turbines need to be imported from other countries, so there are several reasons that it will take more time in unpredicted failures, and for this one it is decided that the turbines have 90% availability.

After the area is chosen, climate data are analyzed, turbine type is selected and losses are determined, the next steps that have to be analyzed are capacity factor, electricity production, overall cost, and payback period of the project.

Capacity factor, displayed in Table 4, is the ratio of the average power produced by the power plant over a year to its rated power capacity. Typical values for wind plant capacity factor range from 20 to 40%. The lower end of the range is representative of older technologies installed in average wind regimes while the higher end of the range represents the latest wind turbines installed in good wind regimes [21]. In this case the capacity factor is 37.5% and its automatically estimated by RETScreen software. Capacity factor is defined by two main factors: shape factor from Weibull distribution and losses.

Table 4. Cost and Export Summary [19]

Summary	Units	
Capacity factor	%	37.5
Initial cost	USD/kW	2100
	USD	155 400 000
O&M costs (savings)	USD/Kw-year	64
	USD	4 736 000
Electricity exported rate	(USD/kWh)	0.086
Electricity exported to grid (%)	MWh	243 357
Electricity export revenue	USD	20 831 346

After the capacity factor is determined, the electricity production from this wind farm can be estimated. Electricity production is varied from all the above factors from site location to climate data, type of turbine selection, losses, and capacity factor. In this case the average wind speed for selected the area is 9.2 m/s at 100 m high from the ground, wind speed distribution from Weibull theory is defined that the shape factor is k = 3. The turbine that we selected is Vesta V90 2 MW - 105 m. Capacity factor is 37.5 % and losses as are shown in Table 4.

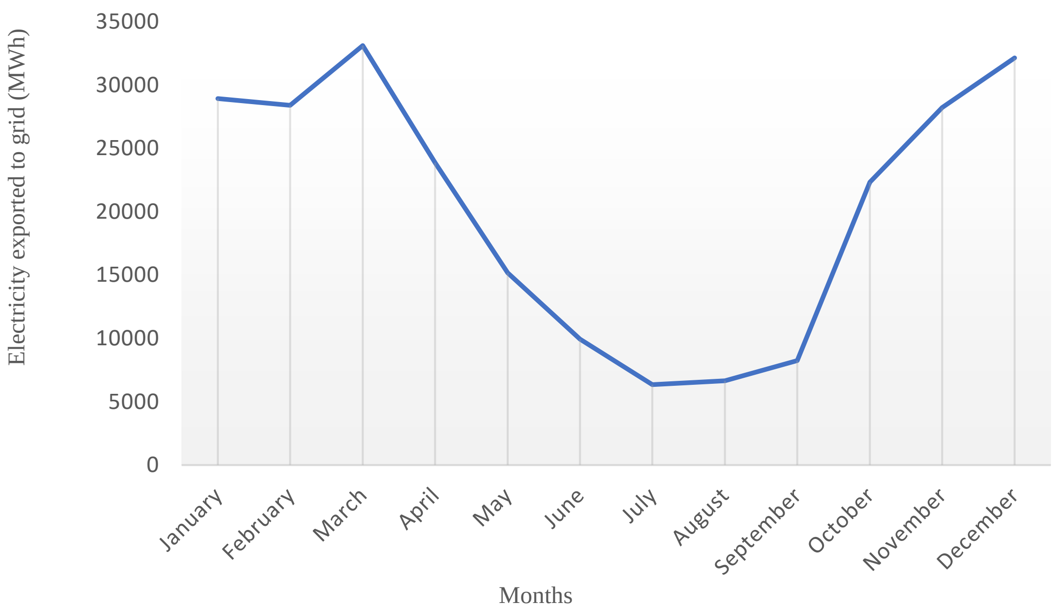

Figure 10. Monthly electricity exported to grid [19]

The calculated electricity production from above data, for a year is 243 357 MWh or 243.36 GWh. Figure 10 presents the monthly values data, for electricity exported to grid in (MWh). The summer months are, months with the lowest monthly average wind speeds, this the reason why there is produced 3-5 times less electricity compared to winter months.

Overall cost of investment includes initial costs and O&M costs. Initial cost is composed of equipment cost and installation cost. In this case the initial cost will be expressed as cost (USD)/KW installed power capacity. Typically, due to economies-of-scale, the larger the capacity, the lower the installed cost per unit capacity [21]. Referred

RETScreen database for an investment with an installed power capacity up to 100 MW, the initial cost is 2100 $/KW. Projected wind farm is 75 MW installed power capacity, which means the initial cost is going to be 155 400 000 $. O&M costs or Operation and Maintenance cost are marginal costs that are associated with operation and maintenance, for example cost of replacement of a transformer. Referring RETScreen database O&M costs, for an investment with an installed power capacity up to 100 MW, are 64 $/kw in a year. So, the O&M costs for a 74 MW installed power capacity, are 4 736 000 $ in a year.

Payback period, shown in Figure 11, is dependent on four main factors which are total cost (initial and O&M cost), debt ratio, electricity production and electricity price that will be exported to grid. The initial cost is calculated 155 400 000 $ while the O&M are 4 736 000 $ in a year. The debt ratio is chosen to be 70% of the initial cost due to high investment initial cost. The duration debt term is 15 years and the debt interest rate 3% in a year. So, the debt payment for a year will be 9 112 129 $. Total annual cost including debt payment and O&M costs will be 13 848 129 $. Mean time the revenue from exported electricity will be 20 831 346 $/year.

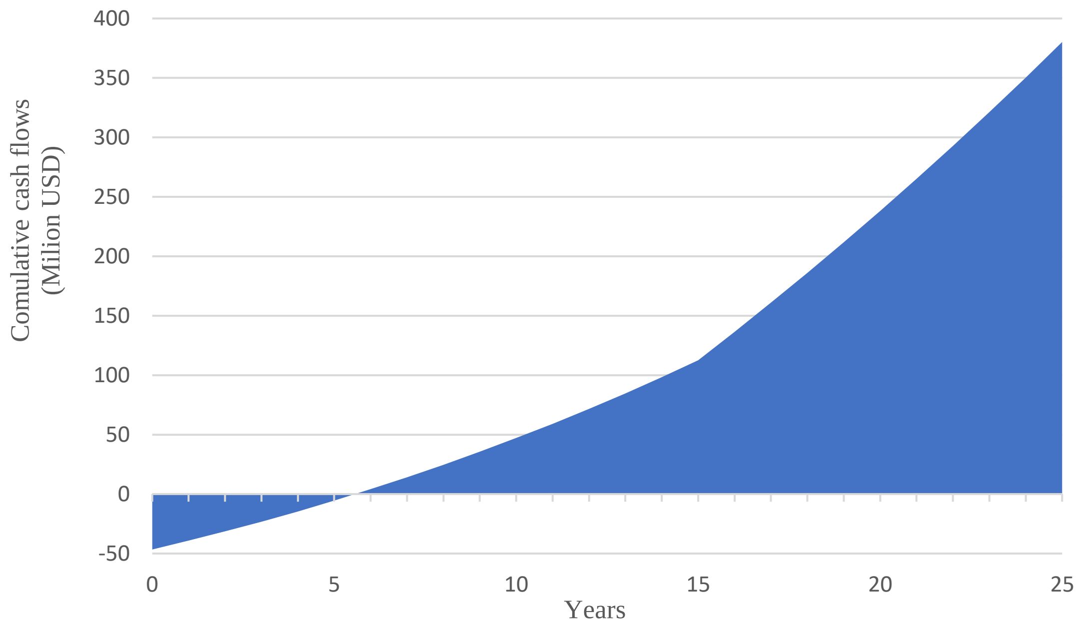

Figure 11. Equity payback period on investment [19]

Electricity price that is exported to grid is referred to electricity price that is exported to grid in 2020, that is 86 $/MWh [25]. While the amount of electricity that will be exported to grid is 243 357 MWh in a year. From those data is calculated that the simple payback is 9.7 years and the equity payback 5.6 years. That means that after 9.7 years, the initial investment is saved, while in 5.6 years, it's only paid back the initial cost, but it's not saved. After 25 years, which is defined as the lifetime of wind turbines, the total revenues from electricity prices starting from equity payback will be 380 223 639 $. There are always possibilities of errors in prediction because there are components that are not able to be predicted as accurately or are not predicted at all. To account for these situations, a risk -15% to +15% of the factors is calculated and displayed in Table 5.

Table 5. Risk analyzation [19].

Parameters	Base scenario	Risk (-15%)	Risk (+15%)
Initial cost ($)	155 400 000	132 090 000	178 710 000
O&M ($)	4 736 000	4 025 600	5 446 400
Electricity exp. (MWh)	243 365	206 853	279 860
Export price ($/MWh)	85.6	72.76	98.44
Debt ratio (%)	70	59.5	80.5
Debt interest (%)	3	2.55	3.45
Debt term (yr)	15	12.75	17.25
Payback year (yr)	5.6	4.76	6.44

5. DISCUSSION

The need for a renewable energy power plant near the city of Vlora has been described in detail in this study. The area to the north of the city does not receive adequate wind speeds, while the southwest region of Albania poses challenges to wind energy due to the gathering of birds and other natural habitats which are protected. Though the coastal regions create ideal conditions for wind farms, displayed in Figure 12, shows why the project was ultimately chosen to go further inland to find an area which can support the project. Being further inland has an advantage of not being as close to the saltwater of the ocean which can elevate the need for maintenance on the turbines. In addition to the wildlife, tourists tend to gather closer to the ocean and a windfarm can cause issues with noise and are seen as having a negative visual impact on the landscape.

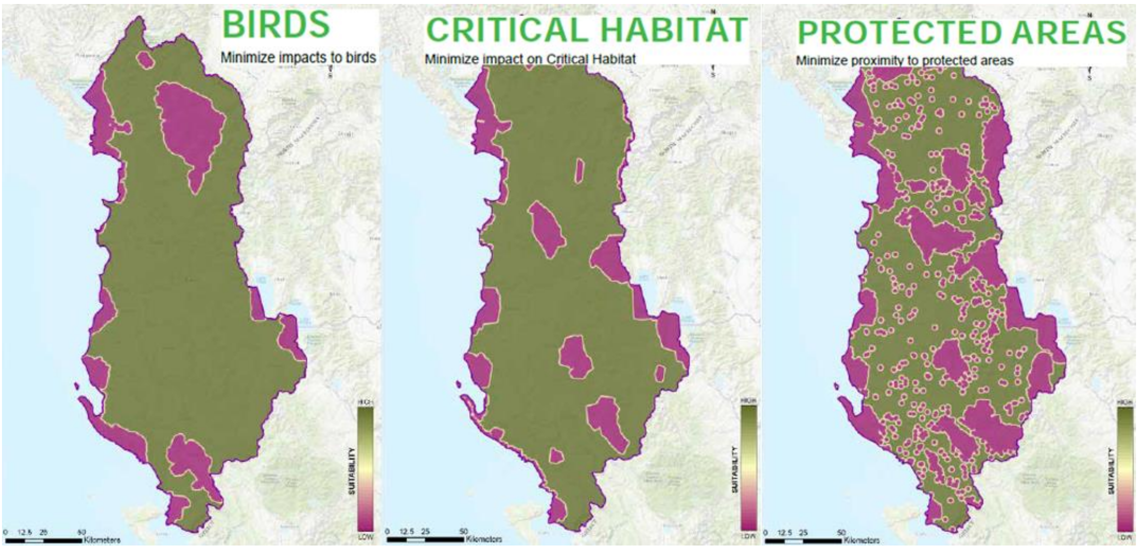

Figure 12. Natural obstacles to a wind farm in southeast Albania [3].

The area which is chosen for this project contains mountain ridges with elevations of up to 2000 meters at the highest peak. The majority of the high points on the ridge are between 1500 and 1700 meter, though. This elevation can cause construction to take longer and become costlier than projected but does not pose an insurmountable task. The projected wind farm location has SH76, an Albanian state road, within 10 km. This is the second highest level of road in the country and should support transportation of the components of the wind farm. A small amount of road will be needed to the site directly. At this elevation, and in this proximity, the windfarm will very well be visible from the state road. It should not, however, cause any major problems with noise pollution. With access to more advanced software, focused on building the layout of a wind farm, this can be more easily visualized from the viewpoints of public roads and populated areas. Such software would also benefit future studies with analysis of detailed placements of individual turbines.

A wind farm of this size would be a significant source of power generation for the city as well as the surrounding county. The county of Vlora has a population of 189k residents which use 1,800.73kWh of electricity on a yearly average per capita [26]. Though these values are set to increase in the coming years, and surges of demand in high tourism summer months, this powerplant could immediately supply 72% of the average yearly energy needs for the residents of Vlora County. Being located less than 40 km from the major city of Vlora will also help to greatly reduce the electrical losses due to transmitting the electricity needed from the northern regions of Albania or importing from neighboring countries.

6. CONCLUSIONS

The present study reports on the need for a renewable energy power plant near the city of Vlora, Albania. The Albanian government is currently offering a tender for onshore wind farm of between 10MW and 75 MW. The objective of the study is to analyze regions, within 50 km of Vlora, which rank highly in suitability to support a wind farm project which would fill the tender requirements. A potential site is identified at 41.33N and 19.83E using a combination of Global Wind Atlas' wind speed map and the wind siting study provided to the Albanian MIE for use by potential developers.

Using further data from Global Wind Atlas, input into RETScreen energy management software, a techno-economic study is performed on the site to analyze its projected performance. This paper proposes a project of 37 turbines, Vesta V90 2MW- 105 m, which can export 243 357 MWh to the grid annually, the project would pay back its equity in 5.6 years while providing 72% of the resident's electrical demands.

In future work, 3D software such as Windplanner, should be used to obtain a more detailed layout for the wind farm. This will allow for a more detailed view of the surrounding terrain and analysis of individual turbine placement. This will aid in identifying previously unforeseen pitfalls as well as engaging potential investors [12].

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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