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An Analysis towards a Sustainable Energy System in Albania Highly Supported by Large Scale Integration of Wind Resources: A Case Study of Mamaj Wind Farm

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ABSTRACT

This article presents a highly important and detailed techno-economic analysis of a grid-connected wind farm, considered as one of the most potential location in the south of Albania, part of Tepelena region, Mamaj village. The procedure of selection of the wind turbine type is performed by evaluating the maximum Capacity Factor (CF) among 15 different types of wind turbines applied using WAsP energy tool enabling the optimization of energy system while economic analysis uses a Monte Carlo simulation well designed on RETScreen Expert tool. This modeling framework can address some beneficial values and solution which can be used from policy makers in the country to better assess the penetration of renewable energy sources into a large scale by finding the exact selling price of electricity and correcting the latest decrease of bonus factor from 1.3 in 2019 to 1.2 in 2020, which should be adjusted by a factor of 1.4. To check the economic feasibility of this project, the parameter of net present value (NPV), internal rate of return (IRR) and simple payback period (SPB) are adjusted accordingly and the financial feasible investment zone is determined.

Keywords: RES, Wind Power, Net Present Value, Internal Rate of return, Discount Rate (r), Simple Payback Period, WAsP, RETScreen Expert
JEL Classifications: Q4, Q42, Q48

1. INTRODUCTION

Renewable energy sources have grown rapidly in recent years, driven by policy support and sharp cost reductions for wind power in particular. Worldwide energy analysts project that annual wind power capacity additions will continue at a rapid clip for the next 10 years driven by the security of energy supply and environmental issues (Gils et al., 2017). The electricity sector remains the brightest spot for sheltering renewable energy sources, building on significant contribution of hydropower power plants in Albania. At the same time, continued technological improvements and cost reductions efforts may lead to enhance the prospects for longer-term growth, which will impact near-term energy policy, electricity market diversification, offering the least-cost options especially in developing countries such as Balkan area (Krajačić et al., 2011, Ilija et al., 2014, Ćosić et al., 2013). In some of the largest wind power markets like most of EU countries identifying as the leader Denmark followed by China and USA, strong growth was driven by looming regulatory changes towards a sustainable and a 100% renewable energy system (Lund and Mathiesen, 2009). There are three major markets for the field of global wind power generation: Europe, USA and China (US Department of Energy, 2018). Renewable energy sources are able to reduce the European Union's dependence on foreign energy imports, also meeting sustainable objectives to tackle climate change and to enhance economic opportunities (Connolly et al., 2010). One of the major economic advantages of harvesting wind energy in Albania is the reduction in the country's economic dependency on hydropower for electricity generation. In most of Europe, the increase in utilization of wind power for electricity has resulted in increased economic stability against fluctuating fuel prices, despite the fact that wind can be a more expensive way of producing electricity (Malka et al., 2020).

Albanian government has considered the promotion of renewable energy use as an important tool of energy policies for the increase of the security for energy supply, economic development, energy sector sustainability and environment protection. The share of RES in the overall energy system of Albania is largely determined by hydropower and firewood (ERE, 2018). Albanian government has been focused on the diversification of its energy system by promoting different renewable energy resources, including wind energy (Strategjia Kombëtare e Energjisë, 2018-2030). The implementation of wind turbines should in Albania must take local interests into consideration and improving security of supply. The total capacity of all wind turbines installed around the globe by the end of 2019 amounted to 6508 GW resulting of 59 GW added wind capacity referring to 2018 with an increase of 9% but leading wind experts from around the world declare that Corona crisis will slow down the markets in 2020 (WWEA, 2019).

Referring to (ERE, 2018) the yearly energy consumption in Albania is estimated at 24 TWh while electricity share is 7.5 TWh, exclusively generated from domestic hydro sources (60%) while the rest is imported into the regional energy market (250.66 ktoe). Referring the last 10 years electricity consumption remains almost at an unchanged rate of 7.5 TWh with population's electricity access 99.94%.

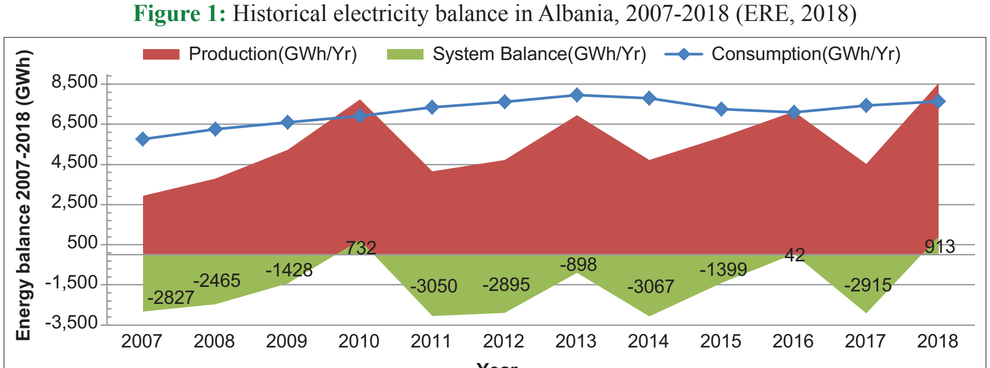
Figure 1 presents the amount of domestic electricity (GWh) production in Albania from 2003 to 2018 (ERE, 2018). From the analysis of the history of electricity production recorded in the country, the year 2018 set a record for the country's electricity production from domestic hydro resources compared to the multi-year average of 5476 GWh. In the graph 2 it is also clearly noticed that as a result of a good hydrological year and the increase of production capacities, the production for 2018 has reached 8552 GWh, corresponding to a good positive balance, which results 13% more than the total annual electricity demand in the country (ERE, 2018). Referring (INSTAT, 2020) net domestic electricity production in the year 2019 reached the value of 5208 GWh from 8552 GWh of energy produced in 2018, marking a decrease in production by 39.1%. The decrease in electricity production has affected the increase of gross imports of electricity by about 1.8 times and the decrease of gross exports of electricity by about 3.5 times, compared to the same period of the previous year. This situation creates and clarifies the idea of better management of energy reserves in the country and the importance of increasing new generation capacities and of course integrating Energy Storage System (ESS) as unenviable option for a large-scale integration of RES (Malka et al., 2020).

The last 10 years, with the exception of 2010, 2016 (small values) and 2018 our country turns out to be a net importer of electricity. After the 1990s, the Albanian economy underwent profound structural changes, moving from a centralized economy to free market. These changes led to an increase in energy demand. After many years of transition, structural changes in the power sector, unfortunately did not provide a clear vision of developing new generation capacities and diversification of energy sources (Malka et al., 2020). Based on this uncertainty of electricity supply, the national energy strategy 2018-2030 was drafted and compiled, which proposes several possible scenarios of transition of the energy system. According to this strategy, the share of RES is intended to reach a target of 42% of the total energy consumption in 2030"and a reduction of 11.5% of CO_2 emissions in 2030 compared to the baseline scenario in 2016 (Strategjia Kombëtare e Energjisë, 2018-2030). Therefore, the Albanian government considers the promotion of renewable energy sources as an important factor in energy and environmental policies. However, the contribution of wind power to the total energy consumption in Albania is remained at 0 MW of installed capacities, even by the end of 2014, 15 companies were licensed but unfortunately no steps towards improving investment have been initiated yet.

With the implementation of law Nr. 7/2017 "On promoting usage of energy from renewable sources," promoting schemes were immediately applied for photovoltaic (PV) plants (up to 2 MW installed power) and wind farms (up to 3 MW installed power).

Historically, the most prevalent national renewable energy policy in the world is the feed-in tariff (UNEP Study, 2012). The tariffs serve as a mean to reduce the risk of a major change in electricity prices and to ensure the investors 'gains (John et al., 2011). According to (Bloomberg, 2013) New Energy Finance, feed-in tariffs have driven 64% of global wind and 87% of global

Figure 1: Historical electricity balance in Albania, 2007-2018 (ERE, 2018)



photovoltaic's capacity. Although the implementation of the Feed-in Premium tariffs for PV plants up to 2 MW in Albania has resulted in 6 contract approvals from the Ministry of Infrastructure and Energy, there are no progress for wind farms up to 3 MW. The competitive process will result in a feed-in tariff which will remain unchanged for a period of time of up to 15 years. This tariff will not be higher than 76 €/MWh which is the amount that ERE has approved for this energy source. It is a significant undertaking for wind developers to assess the feasibility of a large-scale wind farm project, due to the inherent risk associated with the investment (Kealy et al., 2015).

The goal of this scientific work is to evaluate the influence of some technical and financial parameters that impact on cost of capital, simple payback period and calculation of LCOE in the Albanian context by using a case study of a 10.8 MW wind farm project in Mamaj, Tepelena. Exclusively this work is focused to resolve some uncertainties and gaps for future investors and researchers in the field.

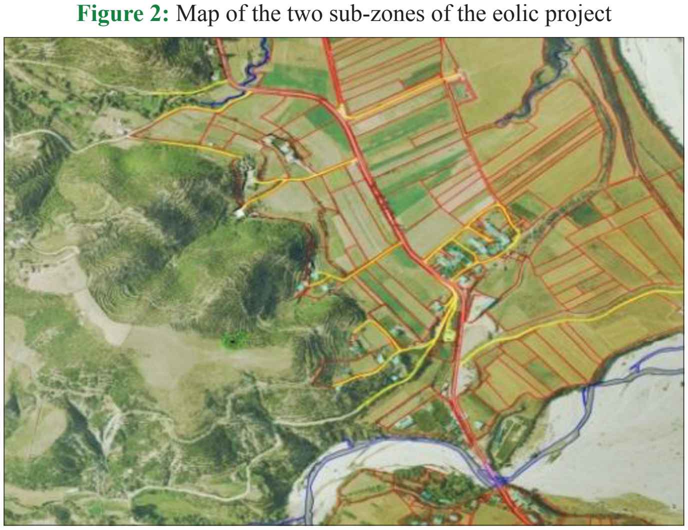
1.1. Site Background

This research work is focused on the wind farm projected to be developed in Mamaj village, Tepelena District, Albania. The proposed installation site of the wind farm is composed of a natural valley near the Vjosa river and relatively low hills not exceeding 150 m as it is shown in Figure 2. Based on the Davenport classification and as the most of the area under study is covered with herbaceous vegetation, the corresponding roughness height is 0.03 m.

Different distribution points of aero-generators is evaluated to maximize the annual electricity production, facilitate road access and solve problems with land ownership if any.

Two previous research study (Malka et al., 2020, Bebi et al., 2015) found that the site with the most wind potential is the area over the hills. Strictly speaking, the direct use of measured wind speed data for wind resource calculations results in power estimates that are representative only for the actual position of the wind-measuring instruments.

Figure 2: Map of the two sub-zones of the eolic project



2. MATERIALS AND METHODS

2.1. Preliminary Wind Resources Study. Energy Tool Selection

In recent millennium, the total number of available energy tools has grown tremendously not in the least because of the expanding computer possibilities, but as a need for fast response calculation. Anyway, these models vary considerably and the question arises which model is the most suitable for a certain case study. The state of the art is not a choosing but conjoining two or more tools, able to work harmonically, with the aim of addressing some benefits in the country context.

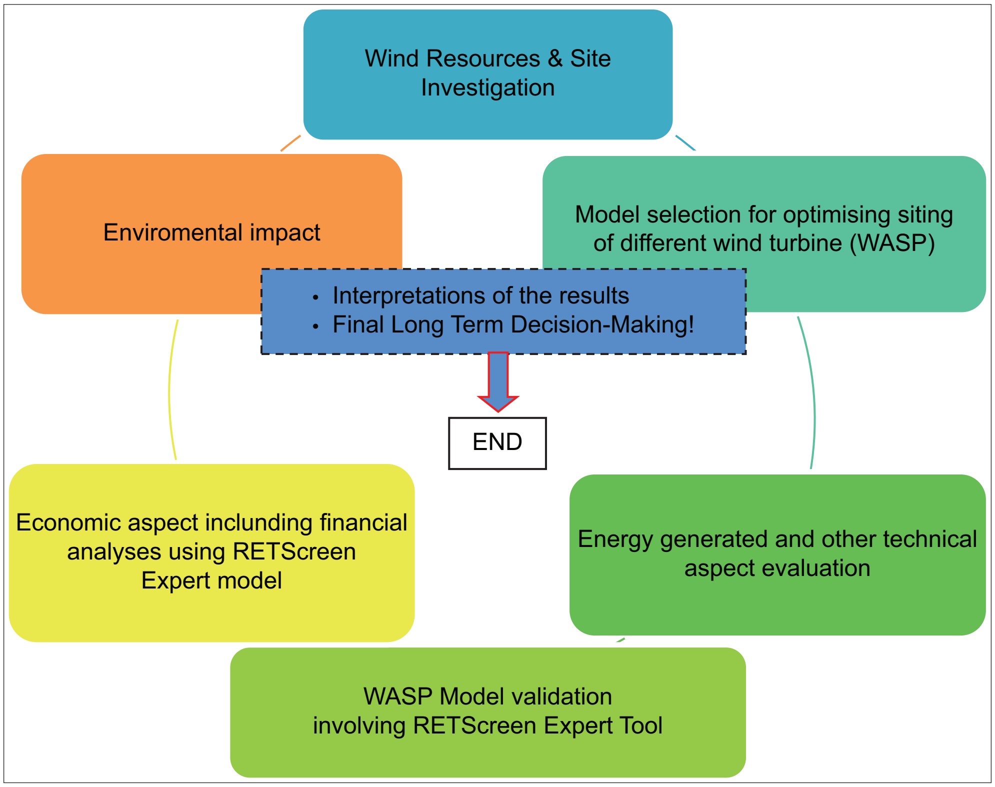
At the beginning WAsP model is used to analyze the capacity and structure of the various wind power systems and then select the most suitable turbine type and model, based on recommendations and trends. Generally, a rigorous assessment requires specific surveys of the region where the wind farm will be placed (Bebi et al. (2015), Curvers and van der Werff (2011), Pitteloud (2018), David (2009), Wiser et al. (2016). WAsP model does not perform economic and environmental impact so that RETScreen Expert, a reliable software to estimate power generation, life cycle costs and mitigation of GHG is selected and a validation procedure is performed. After validation process of technical results by both models the detailed economic and environmental analyses should start correctly in RETScreen Expert model.

This selection is made taking into account both technical and economic context, such as wind potential in the area affecting tower height, installed capacity, rotor diameter and specific yields Figure 3.

2.2. Wind Speed Distribution

Wind speed distribution, when required in the model is calculated in RETScreen and WAsP tool as a Weibull probability density function. This distribution is often used in wind energy engineering, as it conforms well to the observed long-term distribution of mean wind speeds for a range of sites. Weibull distribution can degenerate into two special distributions, namely for $k = 1$ the exponential distribution and for $k = 2$ the Rayleigh distribution (Weibull, 1951). Since observed wind data exhibit frequency distributions which are often well described by the Rayleigh distribution, this one-parameter distribution is sometimes used to represent wind data; however, the more general two-parameter Weibull distribution is used throughout. But in our case study is measured and has a value of 1.374 and 1.29 measured by mast meters fixed at the tower height of 60 m on the hill and valley respectively. A siting procedure is required and well performed in WAsP model which includes some of the following steps: selection the appropriate regional wind climatology; determine the influence of the roughness of the surrounding terrain; determine the influence of nearby sheltering obstacles; determine the effect of local orography (it is well known that at the crest of a hill the wind will often be stronger than over the surrounding terrain, therefore it might be advantageous to place turbines on top of a hill); calculate the resulting Weibull distribution; calculate the mean power by means of the Weibull distribution and the power curve of the

Figure 3: The flowchart of the algorithms used to calculate on an annual basis, the energy production coupling two models, RETScreen Expert and WAsP model. (by authors)



wind turbine. The Weibull probability density function expresses the probability p(x) to have a wind speed x during the year, as follows (Weibull, 1951, Hiester and Pennell, 1981):

The presentation of wind data makes use of the Weibull distribution (Weibull, 1951) as a tool to represent the frequency distribution of wind speed in a compact form. The two-parameter Weibull distribution is expressed mathematically as:

$$p(x) = \left(\frac{k}{A}\right)\cdot\left(\frac{x}{A}\right)^{k-1} \exp\left[\left(\frac{x}{A}\right)^{k}\right] \quad (2)$$

where p(x) is the frequency of occurrence of wind speed *x*. The two Weibull parameters thus defined in equation (2) are usually referred to as the scale parameter C given by (Hiester and Pennell, 1981) in equation (3) and the shape parameter (factor) k. For k >1 the maximum (modal value) lies at values x > 0, while the function decreases monotonically for 0 < k ≤ 1.

This expression is valid for k > 1, x ≥ 0, and A > 0. k is the shape factor, specified by the user into the model. The shape factor will typically range from 1 to 3. For a given average wind speed, a lower shape factor indicates a relatively wide distribution of wind speeds around the average while a higher shape factor indicates a relatively narrow distribution of wind speeds around the average. A lower shape factor will normally lead to a higher energy production for a given average wind speed. C is the scale factor, which is calculated from the following equation (Hiester and Pennell, 1981).

$$A = \frac{\bar{x}}{\Gamma(1+\frac{1}{k})} \quad (3)$$

where $\bar{x}$ is the average wind speed value and Γ is the gamma function.

In some cases, the model calculates the wind speed distribution from the wind power density at the site rather than from the wind speed. The relations between the wind power density WPD and the average wind speed $\bar{v}$ are:

$$WPD = \sum_{x=0}^{25} 0.5 \cdot \rho \cdot (x)^3 \, p(x) \quad (4)$$

where $\bar{v} = \sum_{x=0}^{25} x \cdot p(x)$

where ρ is the air density and $p(x)$ is the probability to have a wind speed x during the year. In our case study using RETScreen Expert, the wind power density results 554 $W\,m^{-2}$.

2.2.1. Energy curve

It is specified the wind turbine power curve as a function of wind speed in increments of 1 m/s, from 0 m/s to 25 m/s. Each point on the energy curve, $E_{\bar{v}}$, is then calculated as given in equation 1:

$$E_{\bar{v}} = 8760 \cdot \sum_{x=0}^{25} P_x \cdot p(x) \quad (1)$$

P_x - Turbine power at speed x
p(x) - is the Weibull probability density function for wind speed x, calculated for an average wind speed $\bar{v}$.

2.2.2. Unadjusted energy production

RETScreen Expert and WAsP software calculates the unadjusted energy production from the wind turbines which represents the energy produced by a wind power plant at standard conditions of temperature and atmospheric pressure. The calculation is based on the energy production curve of the selected wind turbine and also on the average wind speed at hub height for the proposed site. Wind speed at hub height is usually significantly higher than wind speed measured at anemometer height due to wind shear effect. The model uses the following power law equation to calculate the average wind speed at hub height (Gipe, 1995):

$$\left(\frac{v_{z(\text{hub})}}{v_{z(\text{aneom})}}\right) = \left(\frac{z_{(\text{hub})}}{z_{(\text{aneom})}}\right)^{\alpha}$$

It is first required to set the model the values of the respective wind velocities in the study area which may be represented by the monthly average values for the metering height and/or the annual average. Along with the height of the turbine setting, the wind shear exponent, which ranges from (0.1÷0.4), must be set (Petersen, 1989), but in our case, based on real measurements, this dimensionless coefficient results 0.112. By setting into the model, the above-mentioned parameters, the unadjusted energy production results 5476 MWh.

2.2.3. Gross energy production

Gross energy production is the total annual energy produced by the wind energy equipment, before any losses, at the wind speed, atmospheric pressure and temperature conditions at the site. It is used in RETScreen Expert to determine the renewable energy delivered calculated by equation:

$$E_G = E_U \cdot c_H \cdot c_T$$

where E_U is the unadjusted energy production, c_H and c_T are the pressure and temperature adjustment coefficients calculated by the following equations:

$$c_H = \frac{P}{P_0} \text{ and } c_T = \frac{T_0}{T}$$

where P is the annual average atmospheric pressure at the site, P_0 is the standard atmospheric pressure of 101.3 kPa, T is the annual average absolute temperature at the site, and T_0 is the standard absolute temperature of 288.1 K.

From the calculations, the pressure and temperature coefficients result 0.948 and 0.991 respectively. The Gross Energy production (E_G) results 5145 MWh. The total electricity generated by the wind farm is calculated for an average annual speed 6.169 m/s while the pressure measured at the hub height results 96kPa according to the hydrostatic equation, the perfect gas law and the stepwise linear temperature variation assumption, the hydrostatic equation yield (5):

$$\frac{\partial p}{\partial z} = -\rho z \to p = p_0[1 + \frac{L_0}{T_0}(\text{h} - h_0)]^{\frac{g_0 M}{RL_0}} \tag{5}$$

P_0 = static pressure (pressure at sea level) [Pa]
T_0= standard temperature (temperature at sea level)[K]
L_0= standard temperature lapse rate [K/m] = -0.0065[K/m]
h = height about sea level [m]
$h_{0\,=}$ height at the bottom of atmospheric layer [m]
R = universal gas constant = 8.31432 (Nm/molK)
g_0= gravitational acceleration constant = 9.80665 ms^{-2}
M= molar mass of Earth's air = 0.0289644 [kg/mol].

Employing hydrostatic equation (5) and considering the difference between see level and turbine location the pressure at 80 m hub height results 96 kPa. Renewable energy collected is equal to the net amount of energy produced by the wind energy equipment is given:

$$E_C = E_G \cdot C_L$$

where E_G represent the gross energy production, and C_L - the losses coefficient, given by:

$$C_L = (1-\lambda_a)\cdot(1-\lambda_{s\&i})\cdot(1-\lambda_d)\cdot(1-\lambda_m)$$

Where λa; $\lambda s\&i$; λd; λm specify array losses, soil and icing losses, downtime and miscellaneous losses respectively taken into account to calculate the net energy production.

In general the RETScreen Expert model computes with the set data of 98% wind energy absorption rate, 2% of array losses, 1% airfoil soiling of typical values range from 1 to 10%, 3% downtime loss of typical values range from 2 to 7% of gross energy production and 2.2% miscellaneous loss of typical values range from 2 to 6% of gross energy production. All these input parameters are used in Energy model of RETScreen Expert software for the potential sites. The wind plant capacity factor PCF represents the ratio of the average power produced by the plant over a year to its rated power capacity. It is calculated as follows (Li and Priddy, 1985):

$$CF = \left(\frac{E_c}{WPC \cdot h_Y}\right)\cdot 100$$

where E_C is the renewable energy collected, expressed in kWh, WPC is the wind plant capacity, expressed in kW, and h_Y represent the number of hours in a year (8760). According to Betz's Law (Weibull, 1951), no wind turbine can convert more than 59.3% of the kinetic energy of the wind into mechanical energy transformed at the rotor (Cp ≤59.3%) (Weibull, 1951). That is, only 59.3% of the energy contained in the air flow can theoretically be extracted by a wind turbine (Thomas and Cheriyan, (2012), Oliveira (2008)).

Wind energy project plant capacity factors have also improved from 15% to over 30% today, for sites with a good wind regime (Rangi et al., 1992).

3.1. Resources: Wind Resource Assessment

3.1.1. In site wind measurement and WAsP support analysis for turbine selection

This analysis is highly performed using wind characteristics and data from the wind towers installed in the site. This data set was developed as a high spatial and high temporal (5-min and 10-min) resolution data set for wind energy applications. It differs from wind resource data used previously in Albania because the model's period of record is long enough to capture some interannual variability but not long enough to be representative of the long-term. Thanks to this technology it was possible to obtain detailed information on wind speed every 10 min. In (Mathiesen and Lund, 2009, Lund, 2009, it is emphasized that wind speed prediction plays a vital role in the management, planning and integration of the energy system. In previous studies, most forecasting models have focused on improving the accuracy or stability of wind speed prediction. However, for an effective forecast model, considering only one criterion (precision or stability) is insufficient. This information is enough to run and carried out the reference model in the RETScreen Expert energy model. In the case where a pre-feasibility study indicates that a proposed wind energy project could be financially viable, it is typically recommended that a project developer take at least a full year of wind measurements at the exact location where the wind energy project is favorable evaluated to be installed (Maria (2009), Brothers, (1993); CanWEA, (1996), Lynette and Ass, (1992)).

From the wind data collected in the site during the investigation period the variation of the average daily velocity for the year 2013-2014, for the hill and valley siting of selected wind turbine is presented in the Figure 4.

In Figure 4 the average monthly wind speed performance for both hill and valley siting option is given. The highest values are observed during the cold season of the year, while the lowest values are observed in the summer months. The highest and the lowest value of wind speed is reached in March and July, 8.1 (m/s) and 4.7 (m/s), respectively. Annual Weibull shape parameter for valley anemometric tower is evaluated k = 1.290 and a Weibull scale parameter A = 5.575 (m/s). For the hill anemometric tower results show that the shape parameter and scale parameter are respectively k = 1.374 and A = 6.169 (m/s) (Figure 5). Analysis using WAsP as well as an experimental study using the PIV method undertaken at the Fluid Engineering Laboratory for Energy and Environment of the Mie University in Tsu City, Mie Prefecture, Japan, showed that a 3 wind turbine layout on the hill (Figures 6 and 7), had lower wake losses compared to the layout with 4 wind turbines (Bebi et al., 2015).

Furthermore, the wind farm project expanded to 3 wind turbines erected in the valley. As a result, a wind farm with 6 wind turbines V100-1.8 MW (Figure 8) was recommended.

According to a study from Curvers and van der Werff, on the accuracy of cup anemometers, a relative error of ±3.5% in wind speed measurement translates to a 20% error in Annual Energy Production (AEP) at sites with an average wind speed calculated using installed mast meters. As a result, the wind farm 10.8 MW would generate a net total AEP of 30.4 GWh. In the graph in Figure 9 energy and power curve is shown. The curve is designed on values provided by Vestas Company, as this type of turbine is not offered in the library of RETScreen Expert tool. The power production by a wind turbine varies with the wind that strikes the rotor. The power produced as function of the wind speed at hub height is conventionally called the power curve.

Figure 9 shows the power and energy curve of Vestas V100-1.8 MW. When the wind speed exceeds the cut-in speed (3 m/s), the power output increases with increasing wind speed to a maximum value, the rated power; thereafter the output is almost constant. At wind speeds higher than the cut-out speed the wind turbine is stopped to prevent structural failures. The power curve is usually referred to a standard density of 1.225 (kg/m^3) corresponding to conditions of standard sea level pressure and a temperature of 15°C. In our case the power curve applied to a site where the average air density is different from the standard value is commonly assumed to be proportional to the ratio of the site air density to the standard value.

It is understood that this performance is related with the annual performance of several factors, mainly the frequency of cyclonic and anticyclonic barrier formations and the effect of local topography, vegetation type, analyzed in WAsP model. During the preliminary studies, after many inspections as well as interpreting the data obtained from the meteorological stations installed in the area, it is concluded that the proposed region presents a great potential for construction of a national wind farm.

Figure 4: Average velocity values of wind by month measured at tower height of 60 m for Weibull distribution, determined shape parameters: k = 1.290 and k = 1.374 for the valley and hill siting respectively. Measurement period March 2013 - June 2014 (Elena et al., 2015)

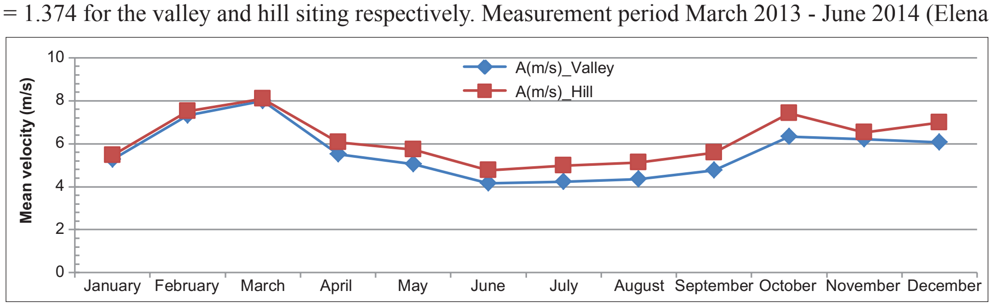


Figure 5: Annual Average value of scale parameter (A [m/s]) and shape parameter (k) measured at a tower height altitude of 60 m, Mamaj, Period March 2013 - June 2014 (Elena et al., 2015)

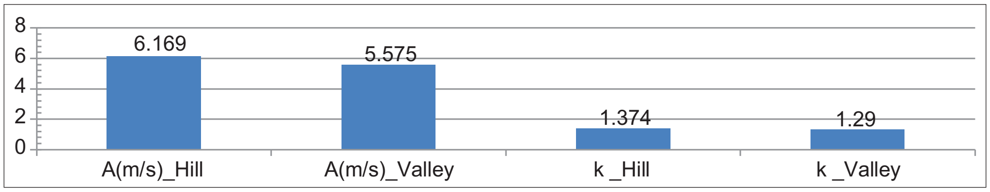


Figure 6: Wind farm of 3 wind turbines

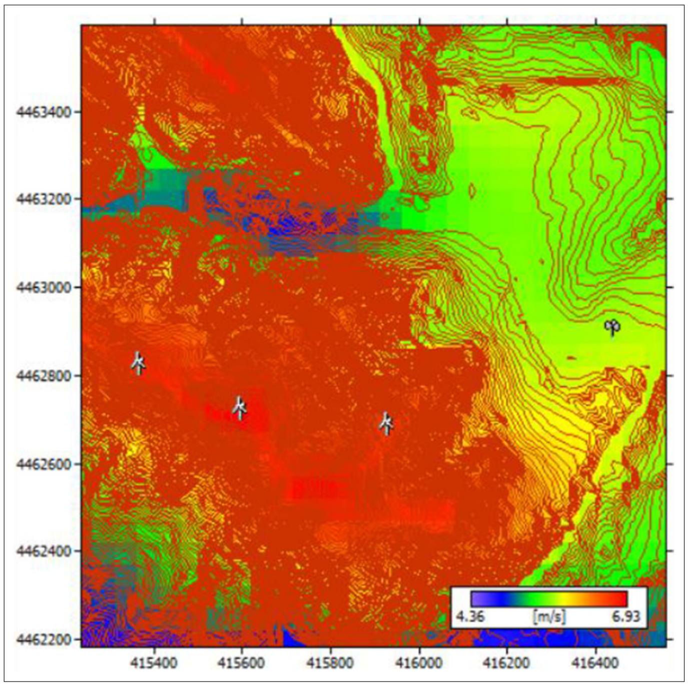
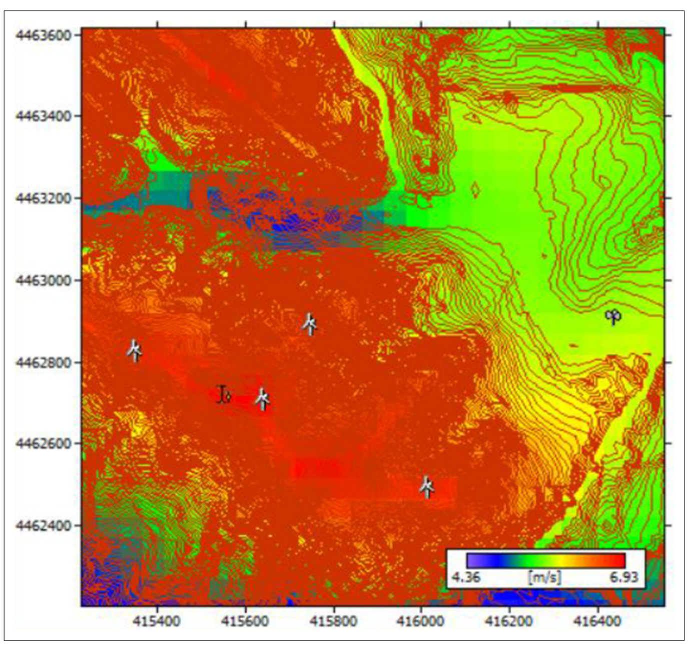


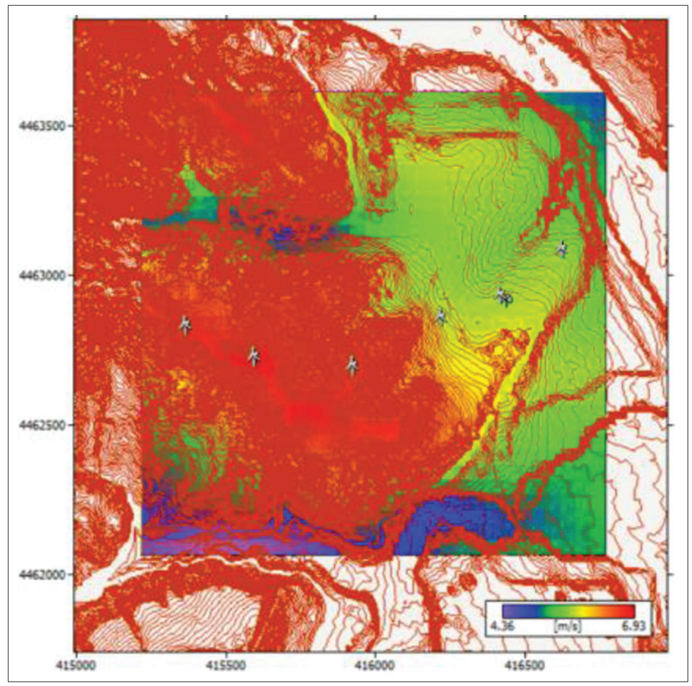
Figure 7: Presentation of economic and financial indicators (by authors)



3.2. Wind Turbine: Results of Turbine Parameters Applied in WAsP and RETScreen Expert Energy Models

The selection of the turbine must meet different criteria simultaneously:

Figure 8: Wind farm of 6 wind turbines (10.8 MW). Total gross AEP (GWh) 34.341 Total net AEP (GWh) 34.003 Proportional wake losses (%) 0.98



- Generate high quality electricity according to specific standards of compatibility with the distribution network (frequency, voltage and harmonic content);
- Operate remotely, with low noise emission and high aerodynamic efficiency;
- Withstand the high variability of wind characteristics;
- Require less maintenance interventions as possible;
- Compete economically with other energy sources.

The following table shows the main key indicators for the turbine type selected in the study. Simulation performed on a set of 15 different types of wind turbines in the WAsP model "shows" Vestas model V100-1.8 MW as the most effective option which afterwards is used and validated on RETScreen Expert tool. The calculated annual electricity and capacity factor CF performed for the same turbine type and simulated in both models are given in the Table 1.

The capacity factor is the fundamental technical criterion in selecting the turbine type as it directly influences the annual energy generated. From the Table 1 the differences between CF calculated independently from both models in similar condition result of 3.22% higher in WAsP model.

Figure 9: This graph provides a representation of the power (kW) and energy (in MWh) delivered by the selected wind turbine measured over a range of wind speeds

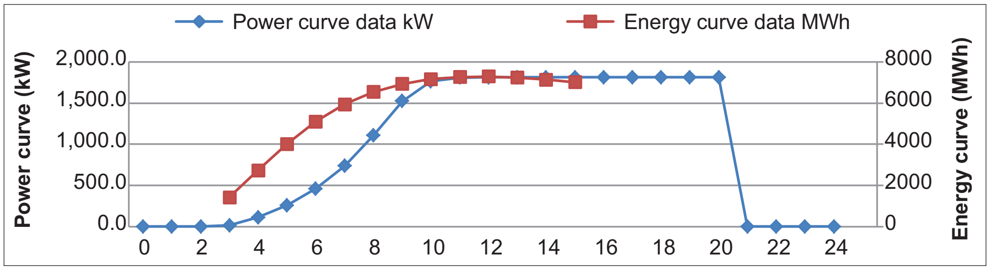


Table 1: Presentation of the technical indicators of the two turbines obtained in the study

VESTAS V100-1.8. MW	Unit	RETScreen Expert	WAsP
Power	MW	1.8	1.8
Number of turbines	Pcs	6	6
CF	%	31	32
Annual energy production	GWh	29.5	30.4
Rotor diameter	m	100	100
Hub height	m	80	80

4. ECONOMIC AND TECHNICAL ASPECTS

4.1. Economics of Wind Turbines

Three key factors are essential when designing wind power plants. First there must be a sufficient source of wind, the wind turbines must be promising as well as cost effective.

This section deals with the economic aspects of building a wind farm with an installed capacity of 10.8 MW and aiming to produce 30.4 GWh/year.

In order to determine the efficiency of the system as a whole, the following factors, variables and indicators of a techno-economic character should be analyzed:

- Levelized Cost of Electricity (LCOE) in electricity production can be defined as the present value of the electricity price produced in c€/kWh, taking into account the economic life of the park and the costs incurred in construction, operation, maintenance, and for fuel. Along this line, the generation cost during construction and production periods can be given expression (6) (Malka et al., 2020; IRENA, 2018):

$$LCOE = \frac{\left[\sum_{N=-1}^{t=-1}\left(\frac{I_t}{(1+r)^t}\right)\right]_{foundation} + \left[\sum_{t=0}^{t=n-1}\left(\frac{F_t + O\&M_t - D_t + T_t}{(1+r)^t}\right)\right]_{prod}}{\sum_{t=0}^{t=n-1}\left(\frac{G_t}{(1+r)^t}\right)_{prod}} \quad (6)$$

- Discount rate (r) is chosen depending on the cost and source of available capital, taking into account a balance between equity and debt financing, estimating the financial risks involved in the project and the context of the country.

We estimated the predicted revenue during a project lifetime of 20 years. However, due to multiple factors, one euro earned or spent tomorrow is not worth the same as one euro today. This concept leads to a technique of economic appraisal known as discounted cash flow (DCF) analysis.

Therefore, to bring back to the present the future net incomes stream that flow every year from the project, we have to know, the discount rate r. The level of the discount rate depends on the risk of the investment (Volker, 2005). The project evaluation technique DCF, was used to measure the economic feasibility of Mamaj, wind farm.

The discount rate is assumed to varies between three chosen values taken into consideration 5, 7 and 11%. Evaluating literature reviews, survey responses, and technology deployment data from Mott MacDonald, Oxera analysis shows that the range for the discount rate of onshore wind varies between 7 and 10% Oxera (2011). In the case of Albania, where there are no existing wind farms, there are high risks associated with unforeseen technical troubles, changing legal conditions, currency risk, effects of inflation, bank interest rates, as well as certain political and regulatory risks, this situation brings to some reasonable assumptions to estimate a high discount rate of 11%.

The net present value of a project is the value of all payments, deducted from the beginning of the investment. If the net present value is positive, the project has a real rate of return which is greater than the real interest rate. If the net present value is negative, the project has a lower rate of return. The net present value is calculated by taking the first annual payment and dividing it by (1 + r). The next payment is then divided by $(1 + r)^2$, the third payment by $(1 + i)^3$, and the n^{th} payment by $(1 + r)^n$, as expressed in equation (7).

$$NPV = \frac{P_1}{(1+r)^1} + \frac{P_2}{(1+r)^2} + \frac{P_3}{(1+r)^3} \cdots\cdots\cdots + \frac{P_n}{(1+r)^n} \quad (7)$$

- Internal rate of return IRR is the value of discount rate that makes the net present value of a project zero (Søren, 2009).

$$0 = \sum_{n=0}^{N}\left(\frac{C_n}{(1+IRR)^n}\right) \quad (8)$$

where N is the project life in years, and C_n is the cash flow for year n (note that C_0 is the equity of the project minus incentives and grants; this is the cash flow for year zero).

- The benefit-cost ratio, (B-C) is an expression of the relative profitability of the project. It is calculated as a ratio of the present value of annual revenues (income and/or savings) less annual costs to the project equity as expressed in the following formula (9):

$$B/C = \frac{NPV + (1 - f_d) \cdot C}{(1 - f_d) \cdot C} \tag{9}$$

f_d is the debt ratio

- Debt payment, Debt payments are a constant stream of regular payments that last for a fixed number of years (known as the debt term). The yearly debt payment D is calculated using the following formula:

$$D = C \cdot f_d \frac{i_d}{1 - \frac{1}{(1 + i_d)^{N'}}} \tag{10}$$

Where C represent the total initial cost the of the project, f_d is the debt ratio and i_d is the effective annual debt interest rate and N' is the debt term in years.

- Installation costs include costs for the extension of the grid and the armature of the grid. In general, for electricity generation technologies, the cost of electricity is primarily affected by tree main components: Capital and Investment cost, Operation and Maintenance (O&M) cost and Fuel cost. The capital cost of wind energy projects is dominated by the cost of the wind turbine itself (including towers and installation). It is known as the upfront capital cost or often referred to as CAPEX. This can be as much as 84% of the total installed cost (IRENA, 2018). As a result, approximately 75% of the total cost of energy for a wind turbine is related to upfront costs (Søren, 2009). Depending on the percent weight, upfront capital cost for a wind farm project in Europe is composed of the following categories Maria (2009):
  - The cost of the turbine which includes the production, blades, transformer, transportation to the site and installation;
  - The cost of grid connection, including cables, sub-station, as well as the connection to the local distribution or transmission network;
  - The cost of civil work, including the foundations, road construction and buildings;
  - Other capital costs, including development and engineering costs, licensing procedures, consultancy and permits and monitoring systems;

Installation costs can vary with location, road construction and network connection. These can amount to about 30% of the cost of the turbines Maria (2009).

High installation costs can be borne, usually when there is a good wind source as the power produced by a wind turbine is proportional to the wind speed in third power.

Operation and Maintenance (O&M) expressed in €/MWh or in % of total investment cost (depends on energy model applied). Wind turbines, like any other industrial equipment, require service and maintenance (known as O&M), which constitute a sizeable share of the total annual costs. Operation and Maintenance (can represent up to [20÷25]% of LCOE (IRENA, 2018)). Operation and Maintenance costs are related to a limited number of cost components, including: insurance, regular maintenance, repair, spare parts, administration and land rent. Some of these cost components can be estimated relatively easily, for example for insurance and regular maintenance. Conversely, costs of repairs and related spare parts are much more difficult to predict. But all cost components tend to increase as the turbine gets older Poul et al. (2008). The cost of wind as fuel is zero. Therefore, fluctuating fuel costs have no impact on wind power generation costs. This is the fundamental difference between electricity generated by wind power and most conventional electricity generation options (Maria Isabel Blanco (2009).

Thus, a wind farm is capital-intensive compared to conventional fossil fuel fired technologies such as a natural gas power plant, where as much as (40÷70)% of costs are related to fuel and O&M (Søren, 2009).

5. PROJECT COSTS

Although the cost of wind energy has dropped dramatically in the last 10 years, technology requires a higher initial investment than traditional fossil fuel generators. Approximately (65-75)% of the cost goes to equipment purchase and the rest is construction costs(IRENA, 2018, Søren, 2009, Malka et al., 2020),

The graph in Figure 10 shows that turbine prices have fallen sharply in 2018, 53% compared to 2015 (Malka et al., 2020, IRENA, 2018).

This is a very positive indicator for the future investment in middle incomes countries including Albania, as the initial cost has a very important impact on the main economic indicators. In our case the initial cost will be restricted to 1.3 m€/MW lower than (Strategjia Kombëtare e Energjisë, 2018-2030).

5.1. Operation and Management Costs

The operation and maintenance of Wind Power Plants is (1.5÷1.7)% of the total initial cost, which is a recommended value provided in (Strategjia Kombëtare e Energjisë, 2018-2030). It is important to mention that references used in our study are obtained from RETScreen Expert database and data collected from studies Maria (2009) in the field of renewable energy sources. The following are the management costs (O&M) - Vestas V100-1.8 MW.

Considering the above recommendations, it is calculated the monetary values expected to be spent during the operational phase (Table 2).

Figure 10: Capital expenditure per MW financed in wind energy, 2015 - 2018 (€ m/MW)

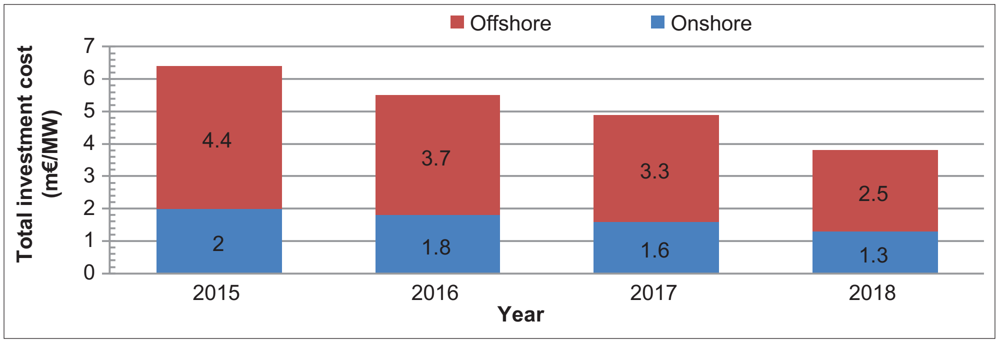


Table 2: Distribution of O&M cost in % (Malka et al 2020)

Components	Recommended costs (%)	Accepted cost (%)	Annual cost (€)
Maintenance	65-80	75.0	220,155
Salaries	4-10	7.0	20,548
Materials	4-10	8.0	23,483
Others	5-10	10.0	29,354
Total		100	293,540

Table 3: Main techno-economic indicators of VESTAS turbine model V100-1.8 MW

Components	Value	Unit
Installed capacity	1.8	MW
Turbine nr.	6	Pcs
Capacity factor (CF)	32	%
Annual wind speed	6.25	m/s
Production	30.4	GWh/year
Sales price	76	€/MW
Investment cost	1100	€/kW
Discount rate	5÷11	%/year
Inflation	2.5	%/year
% e credit	70	%
Inflation rate	3.0	%
Debt term	15	Year
Turbine lifespan	20	Year
(O&M) cost	10	€/MWh
Land lease	Not applicable	Not applicable

Table 4: Investment cost allocation by item in% (Malka et al 2020)

Components	Cost (%)	(%)	Cost (1100 €/kW)
Turbine	65-80	75.0	825
Foundations	4-10	4.0	44
Elect. installations	4-10	4.0	44
Grid connection	5-10	5.0	55
Road construction	1-5	3.3	27
Land acquisition	0-6	0.0	0
Permissions	0-2	1.0	11
Projection costs	3-5	3.0	33
Financial costs	3-5	3.0	33
Infrastructure	1-5	2.5	28
Total		100	1100

5.2. Calculations

As it is shown in Table 3 changing the variables will affect the outcome of the project. It is clear that the turbine size and number drastically affect the outcome but in our work the decision was made to do calculations based on 1.8 MW turbines. It is not possible to alter the wind turbines effect as this changes the basis of the calculated annual power production results from the power calculator software see Table 3.

In the Table 4 the wind farm capital cost breakdown is given as recommended in (Malka et al 2020). Later in economical analyses are performed using these proportional values.

5.3. Techno-economic Selection of Turbine

The technical aspects of turbine type selection directly affect the annual revenue generated by each turbine. In our case study the Vestas Model V100-1.8 MW turbine perform better in WAsP model among 15 different types of turbines taken in the analyses providing the greatest capacity factor of 32%, as discussed earlier. After choosing the turbine model in WAsP model, RETScreen Expert model is required to perform sensitivity and risk analyses of the project which consist on determination of some important financial parameters such as NPV,IRR,SPB, LCOE. Positive NPV values are an indicator of a potentially feasible project. In using the net present value method, it is necessary to choose a rate for discounting cash flows to present value.

5.4. Sensitivity Analysis

Sensitivity Analysis section is provided to help the decision -makers to estimate the sensitivity of important financial indicators in relation to key technical and financial parameters. Each section provides information on the relationship between the key parameters and the important financial indicators, showing the parameters which have the greatest impact on the financial indicators.

In using the net present value method, it is necessary to choose a rate for discounting cash flows to present value. The variation of NPV as a function debt rate within a sensitivity range of 35% for the total installed capacity 1.1€m/MW and a discount rate r=5,7and 11%, are depicted in the graphs in Figure 11 below. An inflation rate of 2.5% and a debt interest rate of 3% is assumed. Higher the debt rate, higher the NPV results. For our case two scenarios are evaluated considering 0% debt rate (investor is more likely to invest alone) and second scenario consider 70% of debt rate within a period of 15 years of debt term over which the debt is repaired. Generally, the longer the term, the more the financial viability of an energy project improves, but it should not exceed the estimated project life. As it is shown in the graph in Figure 11 the impact of debt rate and installation cost extended on sensitivity range has a significantly important role. Consequently, the variation on both debt rate and installation cost must be addressed and fixed when facing real investment condition.

The energy planers use the debt ratio (%), which is the ratio of debt over the sum of the debt and the equity of a project. The debt ratio reflects the financial leverage created for a project; the higher the debt ratio, the larger the financial leverage. The model uses the debt ratio to calculate the equity investment that is required to finance the project.

In the graph in Figure 12 three different levels of the discount rate (%), is used. The rates are enveloped in the detailed analyses to discount future cash flows in order to obtain the real present value.

Figure 11: NPV comparison as a function of installation cost (1.1 m€/MW) and debt rate (70%) extended over a sensitivity range of ±35%, r = (5, 7, 11)%

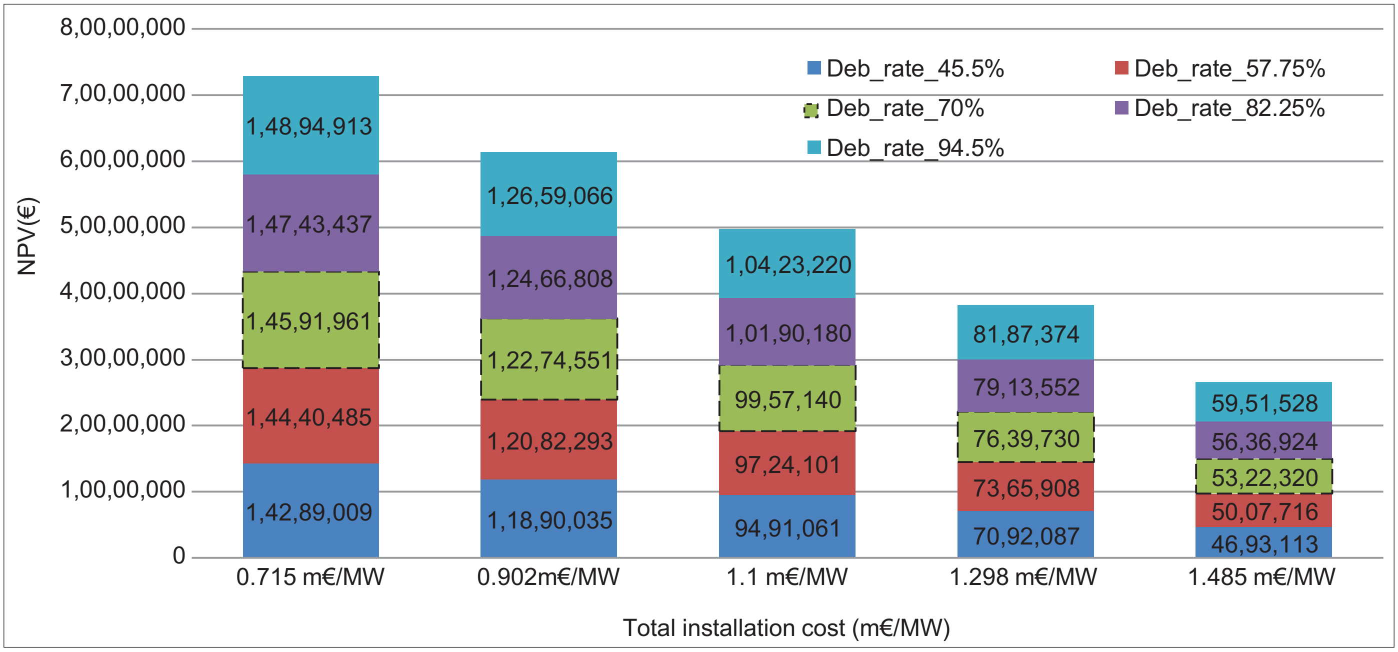


Figure 12: NPV variation for three different values of total investment (m€/MW) cost and discount rate, r = 5, 7, 11%

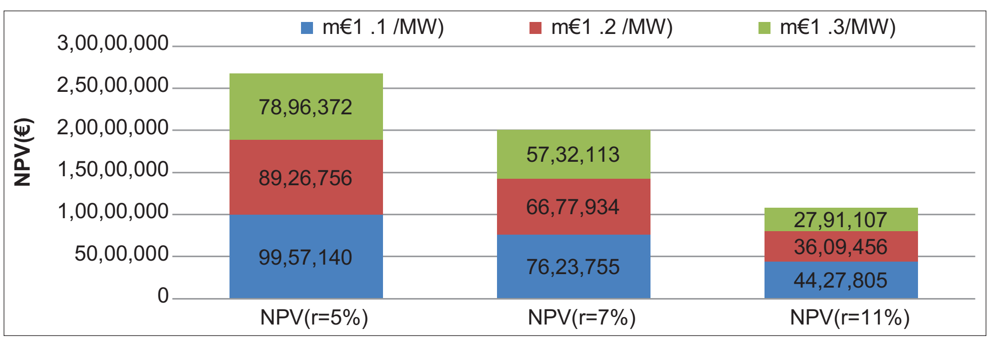
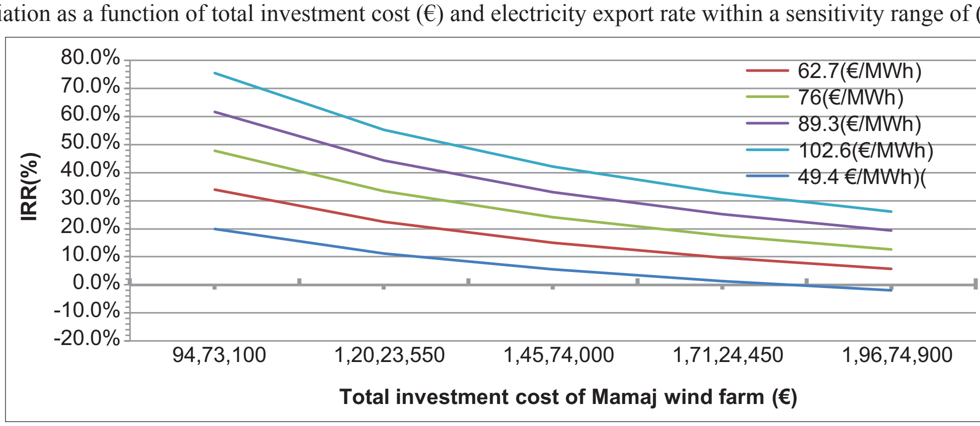


Figure 13: IRR variation as a function of total investment cost (€) and electricity export rate within a sensitivity range of (±35)%, r = (5÷11)%.



To assess the financial viability of a given project is sometimes called the "hurdle rate," the "cut-off rate," or the "required rate of return."

It is clearly shown that the impact of this parameter in NPV is very important as for fixed technical and financial parameters the NPV value decrease as discount rate increase.

By considering a total installation unit price of (1.1÷1.2) m€/MW, an inflation rate of 2.5%, a debt rate of 70% and a debt term of 15 years it is observed that NPV calculated at 5% discount rate reduces by a factor of 2 and by 3 for 1.3 m€/MW case. Increasing the total installation unit cost from 1.1m€/MW to 1.3 m€/MW, the NPV decreases by 26% of the discount rate 5%, 33% and 58.6% if applying 7% and 11% of the discount rate.

Graph in the Figure 13 represents the correlation of IRR as a function of total investment cost (€) and electricity export rate within a sensitivity range of ±35%, calculated for a debt rate of 70%, inflation rate 2.5%. The effect of discount rate variation on IRR is 0%. Thus, in this sensitivity analyses performed it is observed that the optimal value of IRR is 20.9% calculated as the after-tax internal rate of return (IRR) on equity (%), which represents the true interest yield provided by the project equity over its life after income tax. It is calculated using the after-tax yearly cash flows and the project life. Lower the total installation cost of the wind farm higher the IRR results more feasible the project results. Lower IRR values are observed in the level of electricity export rate price 49.4€/MWh for the whole range except the case when the total installation cost results 9,473,100€; 12,023,550€ if the deviation from the supposed total unit price is reduced by 18 to 35% respectively. Negative IRR value of -2% is achieved if the deviation from the supposed total unit price is increased by 35%.

From the graph in the Figure 14, a recommended value of 3% of the debt interest rate is assumed, which represents the annual rate of interest paid to the debt holder at the end of each of 15 years of the debt term chosen in the study. The model uses the debt interest rate to calculate the debt payments which in our case study results 854,570€. By changing the debt interest rate within a sensitivity range of ±35%, than it is observed that NPV changes proportionally following a linear function.NPV results higher for lower interest rate and higher electricity export rate. So as a conclusion, for an electricity export rate of 49.4€/MWh, the project results unfeasible, even the lower rate of the debt interest rate is simulated. Otherwise by reducing the debt interest rate from 3% to 1.95% the NPV value increased only 6.21% referring to 70% of the debt rate, electricity export rate 76€/MWh and r=(5÷11)%. NPV reduces by 7.41% in the case the debt interest rate becomes 4.05%. In the case when electricity export rate becomes 89.3€/MWh the NPV results 4.2% higher and -4.8% lower if debt interest rate becomes 1.95% and 4.05%

Figure 14: NPV variation as a function of debt interest rate and electricity export rate within a sensitivity range of ±35%, r = 5, 7 and11%

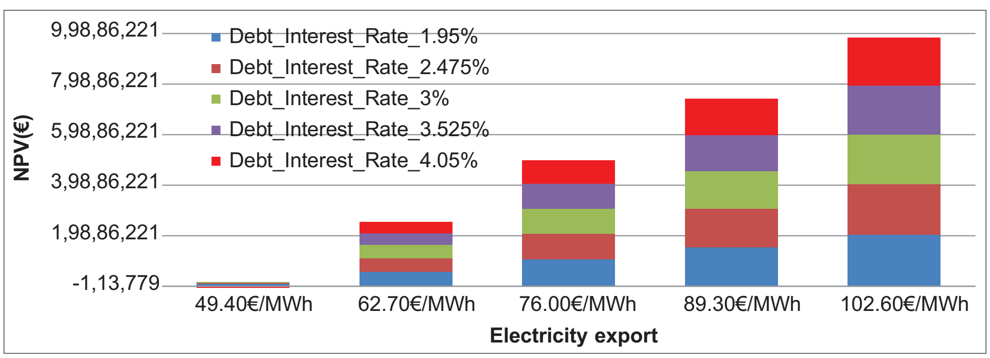
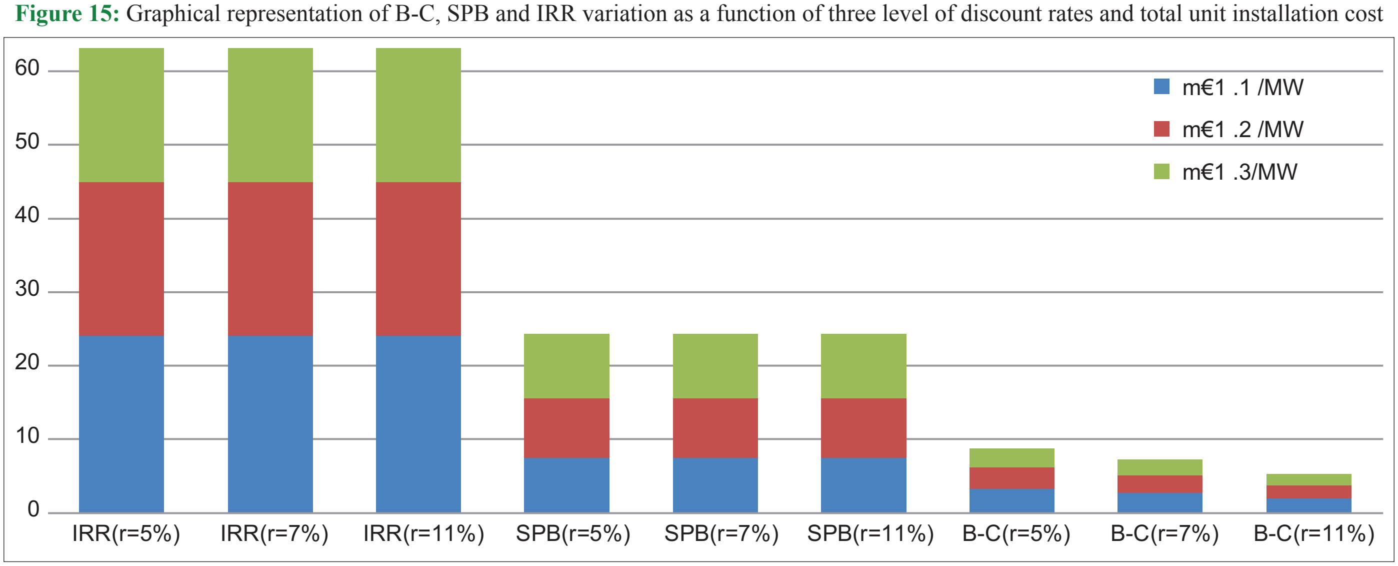


Figure 15: Graphical representation of B-C, SPB and IRR variation as a function of three level of discount rates and total unit installation cost



in respect to that of 3%. The discount rate is controlled and has no effect on NPV when the sensitivity analyses is performed on both above mentioned financial parameters, electricity export rate and debt interest rate respectively. Factors influencing the main economic indicators of the Wind Power Plants such as fixed or variable parameters are chosen in the light of the methodology used by the designer and the best experience in the design of wind turbine power generation plants. In addition, the inflation rate (2.5%), debt rate 70%, maturity 20 years, debt repayment level 15 years, debt interest rate (3%), the benchmark electricity price 76 €/MWh, O&M costs 10 €/MWh and contingencies are accepted 5%. On the basis of these parameters, the estimation of other economic and financial indicators was performed by changing the discount rate (r=5, 7, 11%) and total installation price according to the levels shown in the graph in Figure 15. RETScreen Expert model generates main indicators values for each scenario, thus obtaining the final economic feasibility indicators such as NPV, B-C ratio, IRR, VAT.

From graph in Figure 16 it is shown that discount rate does not affect the value of IRR. As discount rate increases the B-C ratio decreases by 20%, 37.4% and 65% referring to the total installation unit cost 1.3m€/MW. Referring to the total installation unit cost 1.2m€/MW the rate of decrease of B-C results 19.4%, 36% and 63%. Referring to the total installation unit cost 1.1m€/MW the rate of decrease of B-C results 19.7%, 36% and 63%. The influence of discount rate for the three total unit installation price taken in the study is negligible on the simple payback period (SPB). So, lawfulness of linear interpolation can be applied if different values occur on discount rate within the chosen interval. From the analysis performed it is concluded that B/C ratio is inversely proportional to the unit price of the investment, while SPB is proportional to the total unit installation cost.

Under such special conditions the sensitivity analysis provides accurate information about the electricity benchmark price and can address the policymakers to adjust it in accordance with the outputs of this study. The feasible zone recommended fall between the interval of exportable electricity price (76÷89.3) €/MWh and the installation unit price 1.1 m€/MW should be used as the upper threshold.

The results from the economical analysis are shown below in Table 5 where the electricity production is set at 29,354 MWh/year and the electricity price assumed 76€/MWh. The NPV varies depending on the estimation chosen, for different discount rates (%) and total installation costs gives different IRR values, B-C ratio and SPB. Higher the discount rate lower the NPV, IRR and B-c ratio results while the SPB is proportional.

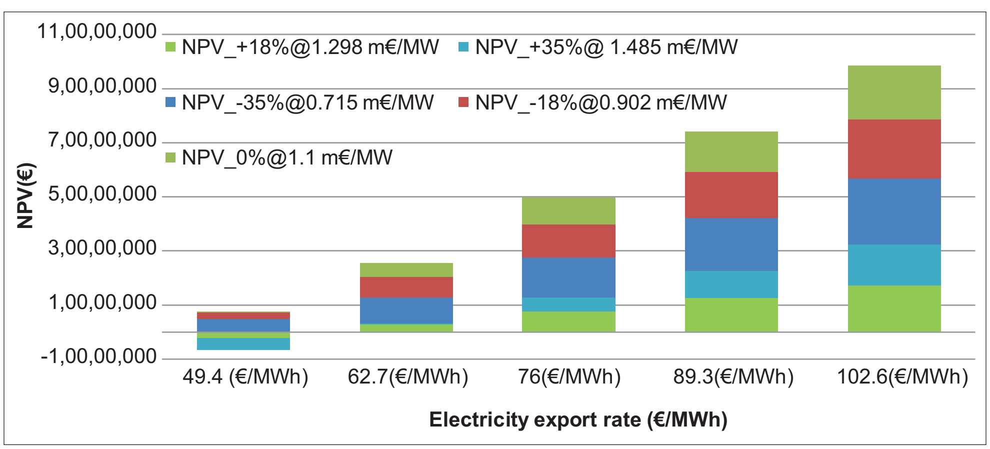
6 RISK ANALYSIS

The Risk Analysis Model in RETScreen is based on a "Monte Carlo simulation," that includes 500 to 5,000 possible combinations of input variables resulting in 500 to 5,000 values performed on Net Present Value (NPV) as it is shown in Table 6. The distribution of possible financial indicator outcomes is generated by using randomly selected sets of values as input parameters, within a predetermined range, to simulate possible outcomes. As a result the risk analysis allows the decision-makers to assess if the variability of the financial indicator is acceptable, or not, by looking at the distribution of the possible

Table 5: Risk analysis reflecting the different key parameters

Perform analysis on			NPV		
Parameter	**Unit**	**Value**	**Range (+/−)**	**Min**	**Max**
Initial costs	€	14,574,000	35%	9,473,100	19,674,900
O&M	€	293,540	35%	190.801	396.279
Electricity export rate	€/MWh	76.00	35%	49.40	102.60
Debt ratio	%	70%	35%	46%	95%
Debt interest rate	%	3.00%	35%	1.95%	4.05%
Debt term	Yr	15	35%	9.75	20.25

Figure 16: Graphic representation NPV, electricity export rate as a function of total installation cost 1.1 m€/MW extended on a sensitivity range of ±35%



outcomes. An unacceptable variability will be an indication of a need to put more effort into reducing the uncertainty associated with the input parameters that were identified as having the greatest impact on the financial indicator.

7. VALIDATION OF THE SIMULATION RESULTS

In this section predictions of the RETScreen Wind Energy Project Model are compared with that of WASP model. The WAsP model is used as a validation of RETScreen Expert results, a deterministic model aims to identify optimal energy system designs and operation strategies using dynamic simulations of a proposed wind farm gathering a set of variables on real conditions Lund (2014), Lund and Henrik, (2017), Ringkjøb et al. (2018), Connolly et al. (2010), Yılmaz et al. (2019). This case study was carried out using WAsP program (Wind Atlas Analysis and Application Program). It is a standard industrial PC-software for wind resource assessment and sitting of wind turbines and wind farms. WAsP creates a vertical and horizontal extrapolation of wind climate statistic. (Mortensen, 2013). It can generalize a series of long term meteorological data from the anemometric tower which can be used to evaluate wind conditions in a larger area where a wind farm would span (Bowen and Mortensen, 1996). WAsP is an implementation of the so-called wind atlas methodology. The WAsP software suite is the industry-standard for wind resource assessment and turbulence mapping, sitting and energy yield calculation for single wind turbines and wind farms, as well as calculation of wind farm efficiency. The WAsP software suite is used for sites located in all kinds of terrain all over the world. This simulation program performs the analysis assuming that the wind velocity data of the investigated region is in a distribution consistent with the 2-parameter Weibull distribution. The WAsP simulation program calculates the regional wind atlas statistics by evaluating four different input information: hourly wind data (wind speed and direction), topography of the area on which the measuring station is located, area roughness information, and obstacle information about the surrounding environment around the wind measurement station. The WAsP simulation program is composed of four Microsoft loader files: the WAsP Climate Analyst, the WAsP Map Editor, the WAsP Turbine Editor, and the WAsP program. The software can be applied to any energy-system, ranging from individual projects to global applications. All thermal generation and renewable technologies can be accounted for using RETScreen Expert and it can incorporate energy efficiency measures relatively easily. However, the only storage/conversion device considered is battery energy storage, and it cannot model any transport technologies. Previously RETScreen has been used to assess the feasibility of wind farm development in many countries like Albania (Malka et al., 2020), financial viability of grid-connected solar PV and wind power systems in Germany Peerapong and Limmeechokchai (2014) the feasibility of solar water heating in Lebanon (Houri, 2005), the viability of solar PV in Egypt El-Shimy (2009), as well as identifying the potential of a building-integrated PV system (Bakos et al. (2003) and GHG reductions in the residential sector (Kikuchi et al., 2009). A detailed assessment of the projects and results completed using RETScreen is available in Peerapong and Limmeechokchai (2014), Leng et al. (2012), Reza et al. (2017).

From Tables 7 and 8 the differences between results from WAsP and RETScreen Expert are given. The results of the simulation shows that both models have very similar outputs leading to small differences in CF and yearly energy production. Both energy models, RETScreen Expert and WAsP can be used by energy planers to better assess a large scale integration of wind power capacities in Albania for a sustainable and reliable energy system based on RES.

7.1. Environmental Impact Analyses

In order to determine how much CO_2 and fuel cost are avoided from wind power investments made in a given year over the entire life-time of the capacity, it is important to remember that investments in wind energy capacity in a given year will continue to avoid fuel cost and carbon cost throughout the 20-25 year lifetime of the wind turbines. Furthermore, in our paper it is assumed that wind energy avoids an average of 0.488 tCO_2/MWh produced; that the average price of a CO_2 allowance is €25/tCO_2 and that €25 million saved per each TWh of energy produced plus €1.5 million considering an oil price of 50€/barrel.

The model calculates the net annual reduction in GHG emissions estimated to occur if the proposed case can be implemented. Natural gas GHG emission factor is calculated 0.488 tCO_2/MWh and transmission loss accepted 10%. The calculation is based on the gross annual GHG emission reduction 12,882.5 tCO_2/year and the GHG credits transaction fee considered 2%. The model then reduces the gross annual GHG emission reductions by this percentage and calculates the net annual GHG emission reduction which results 12,625 tCO_2/year or 29,360 barrels of oil not consumed as it is shown in Figure 17.

8. RESULTS AND DISCUSSION

After studying the wind potential in the village of Mamaj in the Tepelena District of Albania, we envisioned a wind farm with a total installed capacity of 10.8 MW. In order to make a detailed financial estimation of the plant, the values of upfront capital cost and O&M, based on predictions of the business plan of the investing company are used. Referring to a total installation unit price of 1220.4 €/kW provided by the investor of the proposed wind farm. The total installed cost of investment results €14,574,000. In our model total unit installed cost of is considered 1100 €/kW resulting to a total investment cost of €14,574,000 for 0% of sensitivity range. If the installation price reduces by 35% the total investment cost results €9,473,100 (the minimum expected investment) otherwise the price is increased by 35% than a maximum investment sum will result €19,674,900. The total installation unit cost differs significantly between countries. According to Søren 2009 report, the cost per kW typically varies from around 1000€/kW to 1350€/kW. The upfront capital cost (CAPEX), of this Albanian wind farm project is 81% of the total installed cost, which is consistent with the global trends of onshore wind farm projects (IRENA, 2018).

Based on literature reviews, survey responses, and technology deployment data from Mott MacDonald, Oxera analysis shows that the range for the discount rate of onshore wind varies between 5, 7 and 11% (Malka et al., 2020, Oxera, 2011). In the case of Albania, where there are no existing wind farms, is possible to face high risks associated with extra contingencies, currency risk, effects of inflation, bank interest rates, as well as certain political and regulatory risks, it is reasonable to estimate a high discount rate of 11%. The electricity generated by the wind farm is assumed to be delivered at least at a sell price of 76€/MWh during the expected lifetime of the proposed project.

Anticipating the annual energy production around 30.4 GWh, a capacity factor (CP) of 32% for the proposed wind farm project is estimated. Net annual income stream of the wind farm will be €4,427,805 and the simple payback time will be 8.7 years for a discount rate of 11% and 7.5 years at a level of 5% of discount rate. As a result, this means that it will take nearly 7.5 up to 8.7 years of operation for the project to start giving net profit and since the life of the wind energy conversion system is nearly 20 years, the project is found economically feasible.

A Net Present Value of €4,427,805 is provided from the proposed wind project, calculated at 11% of discount rate, 70% debt rate, debt interest rate 3%, inflation rate 2.5%, a debt term of 15 years and an installation cost of 1.1 m€/MW. The NPV increases by factor of 2.48 for discount factor of 5%. The net present value is positive and so the project is feasible and suitable to move forward.

The Internal Return Rate (IRR) of 24%, calculated at 11% of discount rate, 70% debt rate, debt interest rate 3%, inflation rate 2.5%, a debt term of 15 years and an installation cost of 1.1 m€ MW is estimated. In generally, the higher a project's internal rate of return, the more desirable results the investment (Oxera,

Figure 17: GHG analyses of the proposed wind power plant and benefits (by authors)

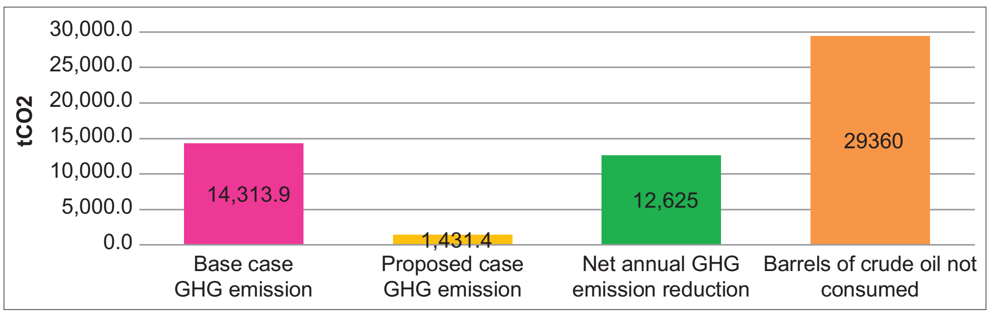


Table 6: Presentation of economic and financial indicators

VESTAS V100-1.8 MW									
Annual electricity generation (MWh/yr)					29,354				
Electricity export rate price (€/MWh)					76*				
Discount Rate (%)	5	5	5	7	7	7	11	11	11
Total installation cost (€m/MW)	1.1	1.2	1.3	1.1	1.2	1.3	1.1	1.2	1.3
IRR (%)	24.1	20.9	18.1	24	20.8	18	24	20.8	18
B-C Ratio	3.28	2.89	2.56	2.74	2.42	2.13	2.01	1.77	1.55
SBP (Year)	7.5	8.1	8.7	7.5	8.1	8.7	8.7	8.1	8.7
NPV (m€)	9.96	8.93	7.90	7.62	6.67	5.732	4.43	3.61	2.80

Table 7: General comparison of WAsP vs RETScreen expert energy tool

	WAsP	RETScreen expert
Organization/Developer	Riso Meteorology Laboratory of the Danish Meteorological Organization	(http://www.retscreen.net/)/Canadian Natural resource
Internationally accepted	Yes	Yes
Usability	High number of licensed users (5000)	Very high number of users (>200 000)
Geografical area	National/State/Regional	User defines
Avaibility	Partly free	Not free of Charge
Equilibrium	No	No
Simulations	Yes	No
Scenario	No	No
Scenario Time frame	No	Max 50 yrs
Specific focus	Yes	No
Energy sectors considered	Electricity	Electricity/Heat
Investment Optimization	No	Yes
One version	Many version	Many version
Environmental Impact	No	Yes

Table 8: General comparison of WAsP vs RETScreen Expert energy tool (by authors)

	RETScreen Expert	WAsP	Differences (%)
Yearly energy production (MWh)	29,534	30,400	3
Total Investment Cost (m€)	1.1÷1.3	1.2	5
O&M Cost (€/MWh)	10	-	-
Capacity Factor	31	32	3

2011). An investment is considered acceptable if its IRR is greater than the investor's minimum acceptable rate of return. The internal rate of return of this wind power project for the 20 years life period was found from the trial and error method of calculation and using a detailed Monte Carlo simulation. Another factor influencing the feasibility of a project is benefit cost ratio B-C which based on a previous study should be at least over 2 (Malka et al., 2020). In our case it results 2.01 and 3.25 in the case of a discount rate 5%. The estimated LCOE of Mamaj wind farm considering a discount rate of 11%, results 0.057 €/kWh, lower compared to the EU value 2016, 0.08$/kWh (IRENA, 2018).

Based on the economic analysis of this study, we show that wind farm projects in Albania follow the general European trend. The most important issue to address is the feed-in tariff, which does not diminish the costs of these capital-intensive projects, but instead helps investors to check in the feasible financial region as given in the Table 7.

The aim is achieving an annual electricity production of 30.4 GWh, equivalent to 4.1% contribution to the total consumption of electricity in our country or 0.12% to the final energy consumption.

For the selected turbine Vestas V100-1.8 MW, based on data collected on wind regime and power law profile formula, the wind velocity at the hub height (80 m) results 6.125(m/s). The benchmark price of electricity, discussed in details in the financial analysis is assumed 76€/MWh. Considering a sensitivity range of ± 35% this price must be the low threshold for an installation cost of (1.1÷1.3) m€/MW.

9. CONCLUSION

This article used a case study of a land-based wind farm project of 10.8 MW to develop economic-evaluation methods that are helpful in determining whether this renewable energy project is economically efficient. Renewable policy is also the important factor for design and economic assessment of the wind farm. Therefore, this paper focuses on preliminary study for the future development of wind energy in the south of Albania. The paper highlights to transmit the wind energy to promising areas and identify the potential regions which should be further investigated in detail for site-specific feasibility analysis.

We proposed a project of 6 wind turbines Vestas V100-1.8 MW making a total installed capacity of 10.8 MW exporting 30.4 GWh/year of electricity into the national grid.

By applying a Monte Carlo simulation in real energy condition, the economic analysis is well extended on cost estimation, electricity price estimation, risk management and IRR calculation, B-C ratio, Pay-Back-Period, NPV as well as a detailed system sensitivity analysis. The aim is achieving an annual electricity production of 30.4 GWh, equivalent to 4.1% contribution to the total consumption of electricity in our country or 0.12% to the final energy consumption. Natural gas GHG emission factor is calculated 0.488 tCO_2/MWh leading to the net annual GHG emission reduction which results 12,625 tCO_2/year or 29,360 barrels of oil not consumed. If the intended capacity of 70 MW will be installed in the proposed area than 185,909 MWh of electricity will be produced and a net reduction of GHG 98,067 tCO_2/year which is equivalent with 228,063 barrels of oil not consumed.

Referring to Hungarian Power Exchange for 2020 the electricity price from RES results 52.96 €/MWh. Furthermore dividing this value with the benchmark price (76€/MWh) considered in the study and the exchange rate €/ALL, the bonus factor from RES should be corrected at least 1.4.

As a conclusion, the last reduced bonus factor to a value of 1.2 intended to be applicable during and later 2020 for the electricity generated from wind power plants will directly affect the financial sustainability of investors facing drought conditions in the last 2 years, and calls into question their ability to repay bank loans taken out for energy plants investments. The results of the study strongly support the outputs and recommendations of the previous study (Malka et al., 2020) in the field of RES. Wind projects in Albania should be considered as an inevitable option for an independent, sustainable and a affordable energy system, developing the remote areas of our country and of course it will play a crucial role in the mitigation process.

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