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Article

The future strategies of the wind power development in Albania : case study: Qafe Thane, Pogradec, Albania

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Malka, Lorenc/Bebi, Elena et. al. (2021). The future strategies of the wind power development in Albania : case study: Qafe Thane, Pogradec, Albania. In: International Journal of Energy Economics and Policy 11 (4), S. 486 - 503.
https://www.econjournals.com/index.php/ijeep/article/download/11228/5962.
doi:10.32479/ijeep.11228.

This Version is available at:
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International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(4), 486-503.

The Future Strategies of the Wind Power Development in Albania: Case Study: "Qafe Thane," Pogradec, Albania

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Received: 22 February 2021 **Accepted:** 19 May 2021 **DOI:** https://doi.org/10.32479/ijeep.11228

ABSTRACT

The development of the electricity sector in Albania continues to be fenced by high rates of inefficiencies, insufficient security of supply, low rate of RES investment including wind power plants and the need to further unbundle and liberalise the energy market following the adoption of the legal basis, including GHG credits is inevitable. A lot of issues are set to face the challenges of energy transition, oriented by the Albanian government's endeavor to maintain a sustainable, secure, flexible in time, efficiently supplied, climate-friendly and affordable energy supply system is required. The most critical aspects to attain 2030 energy goals and beyond cannot be achieved without the promotion of carbonless power technologies reducing (GHG) emissions. As a consequence, huge investments in RES energy based power generation systems and related RES technologies are required. To subjugate the barriers to clean energy technology implementation especially at the preliminary feasibility stage, the latest model, RETScreen Expert 8 added the ability to rapidly analyze the feasibility of multiple wind power plant options at real site condition. This fast feature of the model enables us to assess the real potential of the proposed 27 MW wind farm by choosing a set of 16 different turbine types and models combined into 14 possible scenarios with the aim to expand the capacity in the future is applied. From the simulation executed in RETScreen Expert the technical and economic optimization of the proposed energy system is achieved. Sector-specific actions are explored in the paper, but at the higher level of specific investment costs and a number of cross-cutting actions that should be addressed with urgency from policy makers in the country are identified.

Keywords: Wind Power Plant, HPP, RETScreen Expert, Net Present Value, Internal Rate of Return, Cash Flow
JEL Classifications: Q4, Q42, Q47, Q48, Q58

1. INTRODUCTION

Wind power generation, a clean and free energy form is very essential in today's society development. As the cost of wind power technologies are falling lots of wind power systems have been developed and installed around the globe. Electricity costs from renewables have fallen sharply over the past decade, driven by improving technologies, economies of scale, increasingly competitive supply chains and growing developer experience (IRENA, 2020). Effects of environmental, economic, social, political and technical factors have led to the rapid deployment of various sources of renewable energy-based power generation.

The cumulative capacity of onshore wind has increased more than threefold during the past decade, from 178GW in 2010 to 594GW in 2019 (IRENA, 2020). The estimated global wind potential is evaluated 94,8953 TW while Albania counts for 11,7GW at 50 m height, AEP between 3000 to 25,800 GWh/year (WWEA, 2014).

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%.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, Wiser, R., 2016). Post Covid-19 energy transition investment can boost the economy over the 2021-2023 recovery phase and create a wide range of jobs. Stimulus measures and low installation prices can accelerate positive ongoing tends. In 2019, renewables and other transition-related technologies attracted investments worth $824 billion. In the 2021-2023-recovery phase, the analysis conducted in this report shows that such investments should more than double to nearly $2trillion IRENA (2020). Renewable energy sources, including solar, wind, hydro, biofuels and other future renewable sources are at the centre of the energy transition towards a less carbon-intensive and more sustainable energy system IEA (2020). In the context of GHG emissions, Albanian’s electricity sector is zero emitter in the region as the share of electricity from renewable sources in total electricity generation is almost 100%, while EU-27 32.3% and the border countries Greece 30.3%, North Macedonia 35.1%, Montenegro 59.2% and Kosovo highly depended on lignite has only 5.1%. This would create a good chance to rapidly boost the promotion of RES electricity and sell it in region as well (Wiser, 2016).

In 2019, CO_2 emissions from fuel combustion accounted for the largest share of GHG emissions in Albania, dominated from road transport sector as the rail and others forms of transport has very low weight within the specific-sector itself. More than 75% of CO_2 emissions by fuel combustion came from diesel and petrol engines and oil usage (41.6% and 34.2%, respectively), in 2019 (Eurostat, 2020). By considering the government’s targets and the price competitiveness along with the carbon mitigation potential, wind and PV are realistic options (Nelson, 2014) for future electricity generation.

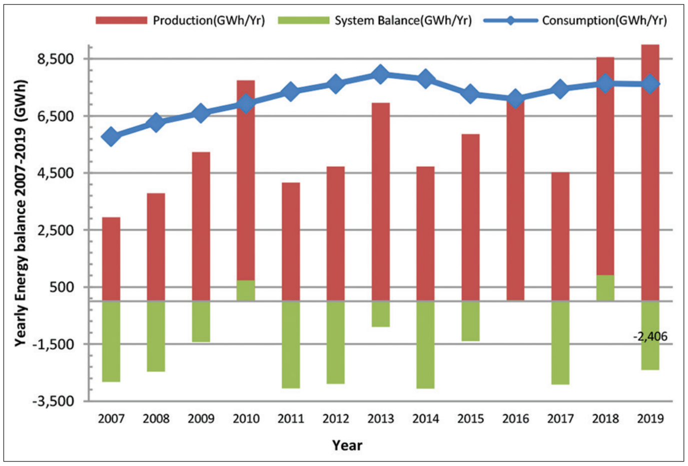
1.1. Albanian Energy System

1.1.1. Electricity sector

In the last few years, Albania has been faced difficulties in providing all electricity demand to its citizens due to a combination of factors, including: lack of primary energy sources; lack of interconnected gas networks; high levels of electricity losses especially in distribution system; limited production and interconnection capacities and high electricity consumption for residential space heating and cooking (ERE, 2019). The total electricity production including owned state HPP and private PP and total demand over the 10 last years is given in Figure 1.

Energy intensity of the economy is 89.5 kgoe per 1000€ in PPS while the energy use in households sector is 178 kgoe/per capita or 710.86 ktoe in total (Eurostat, 2020). The total final energy consumption is 2081.93 ktoe, while electricity sector constitutes, including technical and non-technical losses is around 34.14 % (710.86) of its total consumption. Household sector is responsible for about (50-55)% of the total electricity consumption (ERE, 2019). The total annual energy consumption in 2017 was 24 TWh/year, meanwhile electricity occupies only 31% of its total, which is provided from domestic hydro sources, 60% (389.15ktoe) and the rest is imported in the regional energy market (250.66 ktoe) (ERE, 2019). The leading sector in electricity consumption still remains the residential sector using it for heating and cooking (ERE, 2019).

Figure 1: Yearly electricity balance in Albania (GWh), 2007-2019



The total generating capacity of electricity installed in Albania until 2019 is 2,275 MW, with an increase of 74.3 MW by introducing 36 new power plant producing an annual electricity of 83158 MWh, compared to 2018. The total production of electricity realized by the generation plants that have entered production only during 2019, occupies about 1.6% of the total electricity production, which is a satisfactory value compared to the projected growth performance of electricity demand in the following years. From the graph in Figure 1 it is shown that the electricity demand in 2019 reached the value of 7,612 GWh, a slight decrease of 26,767MWh compared to 2018 (7,638 GWh). The decrease in demand observed during this year, is mainly related to climate change measures undertaken within electricity energy system, energy efficiency or the continuation of measures to reduce non technical losses. The total electricity losses in the distribution and transmission system result 1,651GWh with a reduction of 134GWh compared to 2018. Total electricity generation capacity from the public company KESH sh.a. is 1448 MW constituting 63.47% of the total power installed and the rest 827MW are private own (36.53%) generating 5,206GWh and (2,226 GWh), respectively. Private power plants result with an added contribution of 11.4% more referring 31.6% in 2018. Based on 2019 data the energy situation was facing difficulties as the level of precipitation and inflows marked very low levels, in poor hydrology, leading to a significant import of (2,406 GWh) electricity to meet the total electricity demand. The amount of 5,206GWh was realized by the public KESH sh.a. (2,979 GWh) and other independent private (2,226 GWh) plants with a contribution of 11.4% more referring 31.6% in 2018. Increasing the share of independent producers in the market, is a good hint for the future. An increase of electricity production from 8 existing PV plants with a total installed capacity of 15 MW generating 22190 MWh of electricity is identified. The electricity sector remains the brightest spot for sheltering renewable energy sources, building on significant contribution of hydropower power plants in Albania. In line with (Strategjia Kombëtare e Energjisë, (2018-2030), (ERE, 2019) government has considered the promotion of renewable energy use as an important tool of energy policies to increase the security of energy supply, economic development, energy sector sustainability and environment protection. The RES share within energy system of Albania is largely dominated by HPP and firewood (ERE, 2019). Albanian government has been focused on the diversification of its energy system by promoting different renewable energy resources, including wind and PV energy (Strategjia Kombëtare e Energjisë, (2018-2030); The Albanian Council of Ministers decision 27, 20.1. (2016). The implementation of wind arms in Albania must take local interests into consideration and improving its security of supply.

1.2. Impact of Renewable Resources on the Albanian Electricity Market

The increase in the number of impacts of electricity production from renewable sources such as photovoltaic, hydro and wind power plants, has led to the prerogative preparation of the legal and regulatory framework in Albania enabling absorption, cost reduction and their fair distribution. Investment decisions for the power sector need to account for a balanced mix of variable and dispatchable renewable energy technologies and can pave the way to full decarbonisation.

Flexible grids and storages technologies (IRENA, (2017), U.S. Department of Energy, (2018)) are among the technologies that should be facilitated through centralised planning, fast-tracked licensing and customised loans, while smart meters, batteries and other storage technologies require incentives such as subsidies and tax exemptions.

1.2.1 Clean energy package and Albanian green energy program

1.2.1.1 Global RES policies and Albanian RES initiative

He clean energy package has already been approved with the EU directives, which will soon be mandatory for our country, according to the provisions and obligations of the Energy Community Treaty. The fourth energy package, the so-called Clean Energy Package, focuses on the rights of customers becoming an integral part of the market.

Pursuant to the obligations arising from the provisions of law no. 7/2017 "On promoting the use of energy from renewable sources", ERE has approved the annual purchase price of electricity from existing producers with priority, based on the annual methodology for purchasing electricity.

Renewable energy sources, including wind, solar, hydro, biofuels and other future renewable sources are at the centre of the energy transition towards a less carbon-intensive and more sustainable energy system (IRENA, 2020). Solar and wind energy has played a significant role in the last decade in the process of energy transition in many countries worldwide. Wind mills has attracted massive amount in the global power sector investment over the last couple years, especially in EU-27 countries. To reduce import of electricity, improve its security of supply and to attain the Paris Agreement, the responsible ministry and its sub-ordinate institutions has approved the ***"The National Energy Strategy 2018-2030,"*** consisting on 6 possible scenarios of energy's transition process toward sustainable and reliable energy by shifting Albania to decentralized renewable energy market, and energy efficiency. According to this strategy, the share of RES is intended to reach a target of 42% of the total energy consumption in 2030 as actually this contribution is approximately 30%. The first goal can be achieved by large scale integration of RES capacities, especially wind and PV generation capacities (Malka et al., 2020). The RES share in global electricity generation reached almost 27% in 2019, renewable power as a whole still needs to expand significantly to meet the SDS share of almost half of generation by 2030. This requires the rate of annual capacity additions to accelerate (IEA, 2020). The second goal, compared to the baseline scenario in 2016, should be fully in line with EU objectives, its commitment to reach a reduction of 11.5% of CO_2 emissions by the end of 2030 (Strategjia Kombëtare e Energjisë, 2018-2030). Under the pressure of an increased awareness related to environmental issues, technological progress and the liberalization of the energy market, in the last 15 years has been rapid progress in the development of wind and solar exploitation technologies in Albania. Considerable interest in RES and significant increases in cost of imported oil and very frequent services of related technologies have compelled various countries to search for low-cost energy sources. This must be met by improved technologies hybrid combinations such as wind turbines, PV and synergies between different energy systems. Photovoltaics (PV) is a key technology option for a decarbonised and sustainable power sector and of course limiting the global average temperature rise to 1.5°C to achieve carbon neutrality by 2050 (Jäger-Waldau, 2019). Most of those options rely on renewable necessarily supported from energy storage systems (ESS)) (IRENA, 2020). The electricity sector in our country remains the brightest spot for RES with the strong growth of solar photovoltaic's and wind energy in recent years, already a significant contribution comes from hydropower plants. Electricity accounts for only a fifth of global energy consumption, and the role of RES in the transportation and heating sectors remains a critical matter to a smooth energy transition IEA, (2019), US Department of Energy. (2018). Firstly, a quick and inexpensive initial examination is performed on the pre-feasibility analysis which will determine if the proposed project presents a good chance of satisfying the proponent's requirements for profitability or cost-effectiveness and therefore merits the more serious investment of time and resources required by a feasibility analysis.

2. SITE BACKGROUND AND WIND POTENTIAL

The facility area is around 22 km^2 geographically located at (Lat, Long) 41.04110°, 20.59580°. Measured average annual air temperature, atmospheric mean pressure and altitude above sea level and wind velocity measured at 10m altitude result 11.0°C; 93kPa; 931 m and 2.3 m/s, respectively. Preliminary wind survey includes supposing a number of mast meters located within the site and choosing the best distribution to maximize the power generation (Bebi et al, 2020; Elena, 2015). However, there are some other techniques developed to carry out a fast and costless way of feasibility studies of a wind farm using online weather data provided by RETScreen Climate Database and (NASA, 2015). The installation site will be located in Pogradec near the border with North Macedonia., as it is shown in the map in Figure 2.

From the graph in Figure 3 the yearly wind speed index variation is given. Based on the real data the wind index speed varies in the range of (0.96-1.02) with a frequency of observed values >1 in most of the cases.

The daily wind speed index variation as the most important of all wind characteristics for each hour of a typical day is given. Using this information the annual wind energy for the site is estimated (refer graph 3). The frequency (or number of hours in a year) is then determined (refer graph in Figure 5). The wind speed index is >1.2 in between night hours.

The graph in Figure 5 shows how the wind speed varies considering the whole year's wind speed data. The different hourly wind speeds data is averaged for the year and a graph is plotted, Figure 5.

The graphs in Figure 6(a) shows how wind index speed varies in different months in a yearly context. It would aid in knowing which months have high wind speeds and which has low, consequently helping to decide the type of storage system that would be needed, which will affect the cost and the flexibility of the system. Hence. in my future studies this issue will be the main focus in the context of a sustainable energy sector. In Albania's energy sector there is not applied any other form of energy system, especially to the electricity generation sector leading to high flow rates of water unused leaving the HPP.

Figure 2: Wind power plant location. Qafë Thanë, Pogradec, Albania

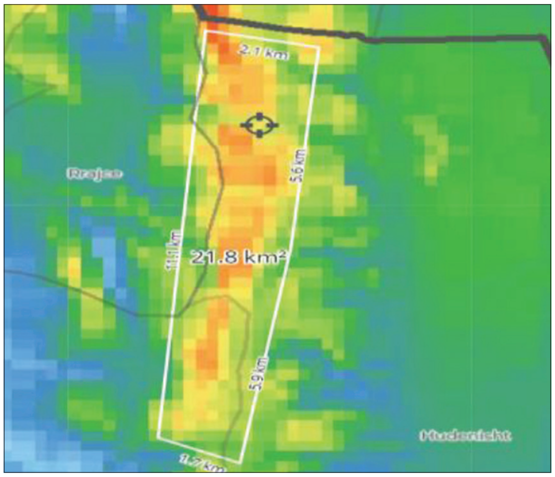
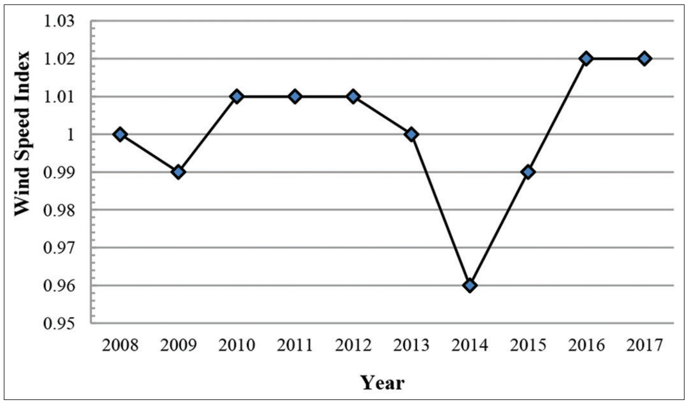


Figure 3: Yearly Wind speed Index variation at the proposed wind power plant location. Qafë-Thanë, Pogradec Albania



In Figure 7 the distribution of the wind speed (m/s) as a function

Figure 4: 1 day Wind speed Index variation at the proposed wind power plant location. Qafë-Thanë-Pogradec, Albania

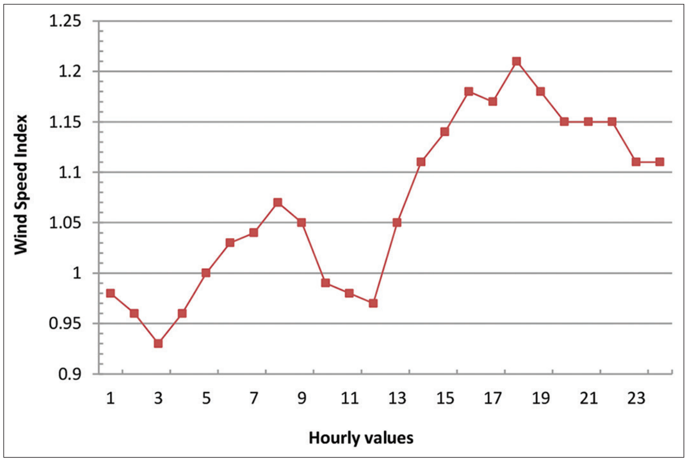


Figure 5: Yearly wind speed index variation at the proposed wind power plant location. Qafë Thanë. Pogradec, Albania

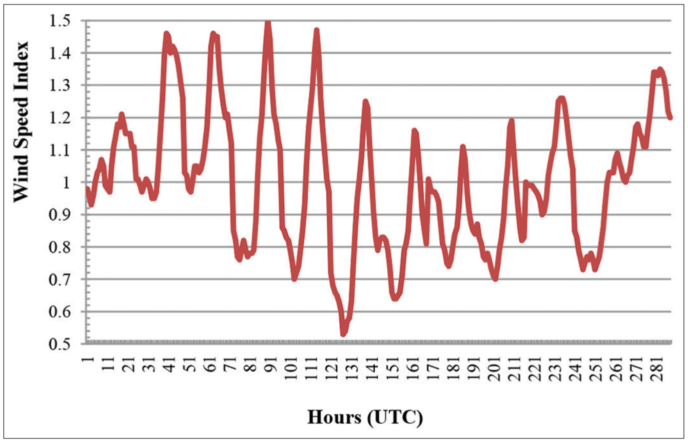
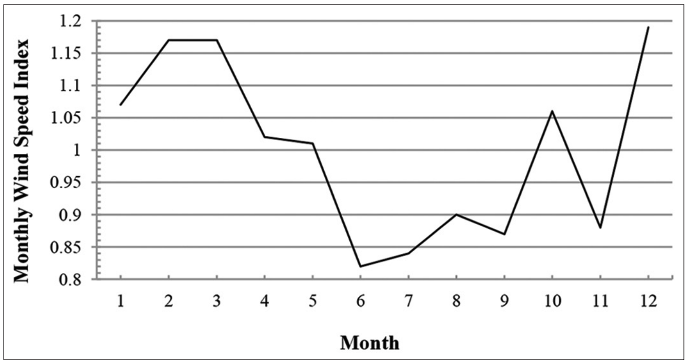


Figure 6: Monthly Wind speed Index variation at the proposed wind power plant location. Qafë-Thanë Pogradec, Albania



of % windiest areas is given. The lowest possible wind speed in 100% of the cases results almost 6.0 m/s, while the maximum value of the wind speed falls 7 m/s in 2% of the cases.

The wind speed duration curve shown in Figure 7 express the number of hours that wind speed exceeds a particular value and wind speed frequency curve shows the number of hours in a year that a particular wind speed will occur.

In Figure 8 the wind regime can be formulated as the distribution of wind power density throughout a year at the supposed wind farm. It can be presented in a wind power duration curve or wind speed frequency curve. A wind speed duration curve shows the number of hours that wind speed exceeds a particular value and wind speed frequency curve shows the number of hours in a year that a particular wind speed will occur (refer graph in Figure 7).

In this study the results from the graph in Figures 7 and 8 are used integrally to check the CF by the way the annual energy output.

3. WIND ENERGY THEORY

3.1. Aerodynamics Principle of Wind Turbine. Betz Theory

Figure 9(a) shows a picture of a possible airfoil, where the moving air travelling on the top of the blade has a greater distance to pass before it can rejoin the air that takes the short cut under the foil. In the case of the airplane wings the air pressure on the top is lower than the air pressure under the airfoil hence it creates the lifting force which hangs it over in the air. In terms of the wind turbine blade, it is more complicated than the aircraft wing. From Figure 9(b) we can find that a rotating turbine blade sees air moving toward it not only from the wind itself, but also from the relative motion of the blade. So that, the combination of the wind and blade motion is the resultant wind which moves toward the blade at a certain angle. The angle of attack which represents the angle created between the airfoil and the wind direction is shown in Figure 9(a). Increasing the angle of attack can improve the lift at the expense of increased drag. However, increasing the attack's angle of attack too much wing will stall and the airflow will creates turbulences and damage the turbine blades.

Figure 7: Wind speed variation at the proposed wind power plant location. Qafë-Thanë, Pogradec, Albania

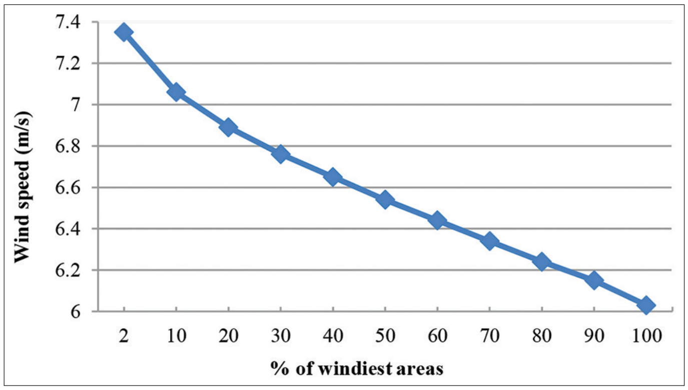
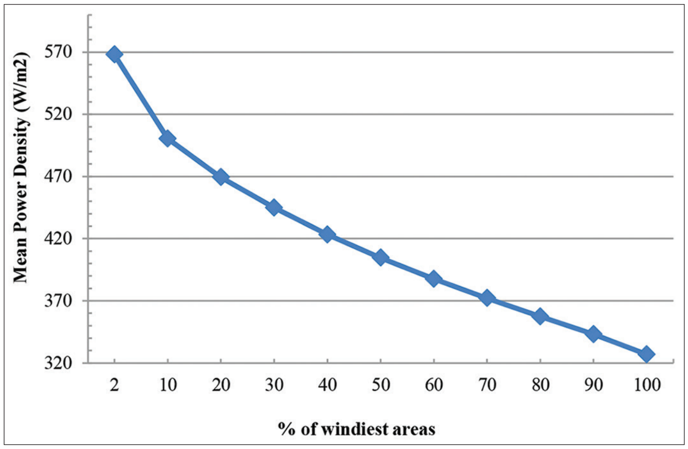


Figure 8: The mean power density for the 10% windiest areas in the selected region 500W/m2. Qafë Thanë, Pogradec, Albania



3.2. Wind Power Availability

The total power available in wind is equal to the product of mass flow rate of wind m_w and $\mathbf{V^2/2}$. Assuming constant area or ducted flow, the continuity equation states $m_w=\rho AV$, where $\boldsymbol{\rho}$ is the density of air in kg/m^3, **A** is the blades area in m^2, and **V** is velocity in m/s. Thus, the total wind power results:

$$P_w = m_w(V^2/2) = \rho A(V^3/2) \tag{1}$$

Here, the $\boldsymbol{\rho}$ is a function of pressure, temperature and relative humidity. Let us assume the inlet wind velocity is $\mathbf{V_i}$, then the average velocity is $\mathbf{(V_i+V_o)/2}$. The wind power recovered from the wind is given as

$$\begin{aligned} P_{out} &= m_w(V_i^2-V_o^2)/2 = (\rho A/4)(V_i+V_O)(V_i^2-V_o^2) \\ So,\quad P_{out} &= P_w/2(1+x-x^2-x^3) \end{aligned} \tag{2}$$

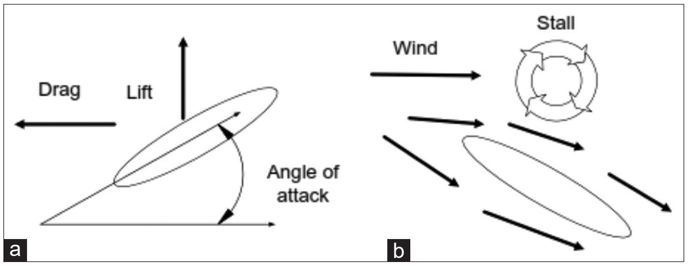
where $x=V_o/V_i$. Differentiating Eq. (2) with respect to x and setting it to zero gives the optimum value of x for maximum power output.

$$\frac{d(P_{out})}{dx} = 0 = (1-2x-3x^2) \tag{3}$$

and then we can get x max p=1/3. By substituting the value of x in Eq. 2 than the maximum of the power is achieved given in Eq.4.

$$P_{out,\max} = 15/27P_w = 0.593P_w \tag{4}$$

Figure 9: The lift in (a) is the result of faster air sliding over the top of the wind foil. In (b), the combination of actual wind and the relative wind due to blade motion creates a resultant that creates the blade lift (Muller and De Doncker, 2002)



It can be found that the maximum power from a wind system is 59.3% of the total wind power known as the Betz Theory.

The electrical power output is calculated from equation 5.

$$P_e = C_p \eta_m \eta_g P_w \tag{5}$$

where $\boldsymbol{C_p}$ is the efficiency coefficient of performance when the wind is converted to mechanical power; $\boldsymbol{\eta_m}$ is mechanical transmission efficiency and $\boldsymbol{\eta_g}$ is the electricity transmission efficiency (Singh, 1995). The optimistic values for these coefficients are C_p=0.45; η_m=0.95 and η_g=0.9, which give an overall efficiency of 38%. For a given system P_w and P_e will vary with wind speed.

3.3. Weibull Distribution of Wind Speed

The sitting procedure includes all of the following steps: selection the appropriate regional wind climatology (Wiser et al. 2016); determine the influence of the roughness of the surrounding terrain; determine the influence of nearby sheltering obstacles (Mortensen, (2013); 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 wind turbine (Hiester and Pennell, 1981).

When the wind speed frequency (distribution) for a site is unknown then the Weibull distribution can be used to estimate the wind speed distribution for a site by putting in Eq. 6 the shape parameter (k) and the scale parameter (c). The Weibull probability density function (PDF) of wind speed, x, p(x) as it is given by Eq. (6). Probability density function gives the probability of occurrence of wind speed between certain intervals. Once the probability is found, this probability is then multiplied with the total annual hours of 8760. This product gives the frequency of wind speed in a year. The frequency of wind speed is then multiplied with the power output from a wind turbine at that particular wind speed.

Wind speed distribution, when required in the model is calculated in RETScreen Expert tool as a Weibull probability density function. Weibull distribution can degenerate into two special distributions, namely for k=1 the exponential distribution and for k=2 the Rayleigh distribution (Weibull, W. 1951).

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:

$$p(x) = \left(\frac{k}{C}\right) \cdot \left(\frac{x}{C}\right)^{k-1} \exp\left[\left(\frac{x}{C}\right)^{k}\right] \tag{6}$$

where *p(x)* is the frequency of occurrence of wind speed *x*. The two Weibull parameters thus defined in equation (6) are usually referred to as the scale parameter C given by (Hiester and Pennell (1981) in equation (6) and the shape parameter (factor) k. For k >1 the maximum (modal value) lies at values $x>0$, while the function decreases monotonically for $0<k\leq 1$.

This expression is valid for $k<1$, $x\geq 0$ and $C>0$, 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 7 (Hiester and Pennell, 1981).

$$C = \frac{\bar{x}}{\Gamma(1+\frac{1}{k})} \tag{7}$$

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:

$$WPD = \sum_{x=0}^{25} 0.5 \cdot \rho \cdot (x)^3 \, p(x) \tag{8}$$

where $$\bar{v} = \sum_{x=0}^{25} x \cdot p(x) \tag{9}$$

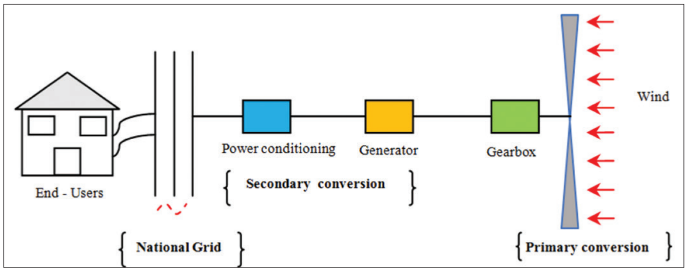
where ρ is the air density and $p(x)$ is the probability to have a wind speed x during the year. In our case study using RETScreen Expert, the wind power density results 500 (W*m^{-2}) refer graph in Figure 8.

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 1.29-1.374 (Bebi et al., 2020).

3.4. Energy Model Selection Criteria

Different professional long-term models for conducting a technical and financial viability analysis of potential energy projects can be chosen. In fact the procedure of selection is mainly depended on many factors such as inputs datas available, possibility to have access freely and the complexity of the system. Generally, RES including wind farm projects so far have been easily applicable

Figure 10: Schematisation of the proposed wind power system



for on-grid level including both central-grid and isolated-grid wind systems. In this work the grid applicability of the proposed wind farm is investigated and given in Figure 10. Thus, an accurate methodology comprehending in-depth analysis of the benefits must be applied and always required. In fact, actually, there are several models available for conducting a technical and financial viability analysis of potential energy projects. RETScreen a clean-energy awareness, decision-support and capacity-building tool (CANMET,1996) is chosen. RETScreen uses a computerized system with integrated mathematical algorithms and top to bottom approach. RETScreen energy tool requires less detailed information and less computational power (CANMET,1996). For instance, other models like HOMER, PLEXOS and EnergyPLAN, use an hourly distribution over an entire year period requiring (8760-8784) individual values, whereas RETScreen Expert uses the annual or average monthly values. The comparison between different energy tools is given Ringkjøb et al. (2018). A comparison between RETScreen Expert tool and more in-depth models using hourly values showed that they produce very narrower yearly results, less than 5% differences are evidenced in previous studied from (Malka, Lorenc et al. 2020., Bebi, Elena et al. 2020). RETScreen has been used to assess the financial viability of grid-connected solar PV and wind power systems in Germany (Peerapong, Prachuab, 2014) the feasibility of solar water heating in Lebanon (Houri A.2006), the viability of solar PV in Egypt (El-Shimy M., 2009), as well identifying the potential of a building-integrated PV system (Bakos GC, 2003) and GHG reductions in the residential sector (Kikuchi E, 2009). A detailed assessment of the projects and results completed using RETScreen is available in ((Peerapong, Prachuab, (2014) and Reza, Seyyed et al. (2017)).

To subjugate the barriers to clean energy technology implementation especially at the preliminary feasibility stage, the latest features of the RETScreen Expert 8 model is improved and one can rapidly analyze the feasibility of multiple wind power plant options (scenarios), at real site condition leading to the least possible cost-generating by combining different wind turbines and technologies.

The software does not provide the possibility of integrating or finding the best energy storage system form and type. However, the next coming RETScreen model will be more implemented by adding the ability of selection and sizing the EES.

3.5. Energy Curve

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 is given in Eq.10. As a result each point on the energy curve, $E_{\bar{v}}$, is calculated:

$$E_{\bar{v}} = 8760 \cdot \sum_{x=0}^{25} P_x \cdot p(x) \tag{10}$$

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

3.6. Unadjusted Energy Production

RETScreen calculates the unadjusted energy production from the proposed wind turbines. It is the energy a wind power plant will produce at standard conditions of temperature and atmospheric pressure. The calculation is based on the energy production curve of the selected wind turbine and on the average wind speed at hub height. 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 Eq.11 to calculate the average wind speed at hub height (Gipe, P. 1995):

$$\left(\frac{v_{z(\text{hub})}}{v_{z(\text{aneom})}}\right) = \left(\frac{z_{(\text{hub})}}{z_{(\text{aneom})}}\right)^{\alpha} \tag{11}$$

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 values. Along with the height of the turbine setting, the wind shear exponent, which ranges from (0.1÷0.4) must be set (Petersen, Lundtang, 1989). Based on wind characteristics and orography of the terrain) results 0.14, then the model automatically calculates the unadjusted energy production of 4,472 MWh.

3.7. 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 derived from the unadjusted energy production, the pressure adjustment coefficient and the temperature adjustment coefficient and calculated from Eq.12:

$$E_G = E_U \cdot c_H \cdot c_T \tag{12}$$

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 13 (a),(b):

$$c_H = \frac{P}{P_0} \text{ and } c_T = \frac{T_0}{T} \tag{13}$$

where P is the annual average atmospheric pressure at the site while P_0, T_0 refers to standard atmospheric pressure and temperature of 101.3 kPa and 228.1K, respectively. The model calculates the pressure and temperature coefficients 0.918, 1.014, respectively. By using the values (P_0,T_0) in Eq. 13 and substituting in Eq.12 the gross energy production of 4163MWh, is calculated. The pressure variation at real height condition at the hub height is given by the hydrostatic equation (14). The perfect gas law and the stepwise linear temperature variation assumption, the hydrostatic equation yield (14):

$$\frac{\partial p}{\partial z} = -\rho z \rightarrow p = p_0[1 + \frac{L_0}{T_0}(\text{h} - h_0)]^{\frac{g_0 M}{R L_0}} \tag{14}$$

Using hydrostatic equation (14) applied at different site location a value of 93kPa at (80-120)m of hub height is calculated. Renewable energy collected is equal to the net amount of energy produced by the wind energy system and calculated from Eq.15:

$$E_C = E_G \cdot C_L \tag{15}$$

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

$$C_L = (1-\lambda_a)\cdot(1-\lambda_{s\&i})\cdot(1-\lambda_d)\cdot(1-\lambda_m) \tag{16}$$

Where λ_a; $\lambda_{s\&i}$; λ_d; λ_m specify array losses, soil and icing losses, downtime and miscellaneous losses, respectively, are applied to calculate the net energy production.

For on-grid, the model computes with the set data such as the average availability energy absorption rate of 98%, 2% of array loss, 1% airfoil soiling, 3% downtime loss of gross energy production and 2.2% miscellaneous loss of gross energy production are applied. 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 and calculated in Eq.17 (Li and Priddy, 1985).

$$CF = \left(\frac{E_c}{WPC \cdot h_Y}\right)\cdot 100 \tag{17}$$

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).

4. THE PROPOSED WIND ENERGY SYSTEM

A wind energy conversion system (WES) is composed of blades, an electric generator, a power electronic converter, and a control system, as shown in Figure 10. The WES can be classified in different types, but the functional objective of these systems is the same: converting the wind kinetic energy into electric power and injecting this electric power into the electrical load or the utility grid or simply to the end users consumers.

Today, wind energy is the fastest growing energy source, but the first wind turbine for electricity generation was developed at the end of the 19th century. From 1940 to 1950, two important technologies, i.e., three blades structure of wind turbine and the AC generator which replaced DC generator were developed. During the period of 1973 to 1979, the oil crises led to lots of research about the wind generation. At the end of 1990s, wind power had an important role in the process of constructing a sustainable energy system. At the same time, wind turbine technologies were developed in the whole world, especially in Denmark as a leading country, Germany, and Spain. The cost of manufacturing WES has plummeted dramatically in the last decade, making them not only affordable but often the cheapest form of electricity. As a result, WES is one of the fastest-growing renewable energy technologies, and is ready to play a major role in the process of grand electricity transition toward 100% RES system in Denmark. The Danish government push the idea to construct artificial island as a wind energy hub believed to be the biggest in its history, which will be located 80 kilometers off Denmark's west coast, will initially be 120,000 square meters in size. This investment will link hundreds of wind turbines to deliver enough electricity for millions of households and is expected to cost around 210 billion Danish crowns (DW, 2021).

5. SOME IMPORTANT WIND ECONOMIC ASPECTS

Generating electricity from the wind makes economic as well as environmental sense; the wind is a free, clean and renewable fuel which will never run out as it is repeated continuously. Even though wind is free its cost of electricity however, is not free. There are initial capital cost of purchasing wind turbines, towers, transportation of materials, labor charge, expertise charge, operation and maintenance cost, etc. turbines are becoming cheaper and more powerful, with larger blade lengths which can utilize more wind and therefore produce more electricity, reducing the cost of power generation. There are two main factors which affect the cost of electricity generated from the wind and therefore its final price which depends upon: (i) technical factors, such as wind speed and the nature of the turbines and (ii) the financial perspective of those that commission the projects, e.g., what rate of return is required on the capital, and the length of time over which the capital is repaid. To be economically viable the cost of making the electricity has to be less than its selling price provided by (ERE,2019).

It is extensively known that the cost of energy will be low if the site proves a high wind potential, the wind turbine optimally matches the wind characteristics for the site and cost of wind turbine and installation is low. Before investment decisions in the field are made it is very important and necessary to determine the electrical energy output from the site.

Any cost from the beginning of investment initiative until the first day of operation including land preparation, site, equipment, transport, design, consultancy, project management, and other financial aspects, need to be "cited on" over the life time of WECS. This deep economic analysis of such projects is influenced by the fact that wind farm projects require a set of millions of moneys to invest thus a level of risk is accepted.

From the key findings of the economic analysis the production cost of electricity generation, NPV, SPB and the effect of the different parameters is determined. In fact based on real inflation rate, reinvestment rate, discount rate, debt term, electricity selling price and GHG reduction rate are some of the vital factors that should be known before starting of any wind energy project idea.

5.1. Investment Cost

Any cost from the start of the idea until the date of operation which includes land preparation, site, equipment, transport, design, consultancy, project management, etc., are "written off" over the lifetime of WFS.

5.1.1. Capital costs

The determination of the capital or total investment cost generally involves the cost of wind turbines and its auxiliaries, i.e., tower, wiring, utility interconnection or battery storage equipment, power conditioning unit, etc., and delivery and installation charges, professional fees and sales tax.

5.1.2. Financing costs

Wind energy projects have intensive amount of money to be invested in the beginning so that the purchase and installation costs are met. For this reason, the developer or purchaser will pay a limited down payment of 10–20% and borrow the rest. The source of capital may be a bank or investors where the lenders will expect a return. The return in the case of a bank is referred to as the interest. Over the lifetime of the project, the cumulative interests can add up to a significant amount of the total investment costs.

5.1.3. Recurring costs

Recurring cost includes operation and maintenance (O&M) cost (administration, labor, spare parts, consumables, lubrication), fuel cost, and capital cost (interest on outstanding capital and transaction costs). This type of cost is included in the BOS and miscellaneous costs is considered 3%. In the total initial cost cell is included training and commissioning which will involve 10 people for 20 days at a rate of $1,800per person-day based on the capacity of the wind project.

5.1.4. Operation and maintenance costs

According to Danish Wind Industry Association, O&M costs are very low when the turbines are brand new but increase as the turbine gets old. The O&M costs generally range from 1.5% to 3% of the original turbine cost. Annual operating costs also include battery replacement every 3-10 years, depending on the battery type and the number of discharges, which is not foreseen in this research study.

5.1.5. Avoided cost based value of wind energy

The traditional way to assess the value of wind energy is to equate it to the direct savings that would result due to the use of the wind rather than the most likely alternative. These savings are often referred to as "avoided costs". The avoided costs include fuel and capacity costs and is not considered in this research study.

5.1.6. Environmental value of wind energy

The primary environmental value of electricity generated from wind energy systems is that the wind offsets emissions that would have been caused by conventional fossil fuelled power electricity generation plants. These emissions include sulphur dioxide (SO2), nitrogen oxides (NOX), nitrogen oxides), particulates, slag and ash. The amount of emissions saved via the use of energy depend on the types of power plants that are replaced by the wind system, and the particular emissions control systems currently installed on the various fossil-fired plants which in our case study is considered oil 6 type.

6. MARKET VALUE OF WIND ENERGY

The market value of wind energy is the total amount of revenue one will receive by selling wind energy or will avoid paying through its generation and use. The value that can be "captured" depends strongly on three considerations; the market application, the project owner or developer and the types of revenues available. In remote areas the environmental, social and legal factors are least affected.

6.1. Economic Analysis Methods

Economic analysis can be conducting using neither "**Absolute analysis"** by checking if the costs are higher or lower than the benefits? or "**Relative analysis"** especially for RES projects such defining the rank of the proposed wind farm in terms of costs and benefits.

- Cost-benefit analysis: A time period is chosen and the sum of all costs and benefits in that period is determined. The net benefit is determined by subtracting total benefits and total cost in that time period.

$$\text{Total Benefit}=\sum(\mathit{benefits})-\sum(\cos ts) \tag{18}$$

- Benefit to cost ratio (BCR): A time period is chosen then the sum of all costs and benefits in that period is determined. The ratio of benefit to cost gives the benefit to cost ratio.

$$\text{BCR}=\frac{\sum(\mathit{benefits})}{\sum(\cos ts)} \tag{19}$$

- Simple payback period (SPB): This is one of the most common ways of finding the economic value of a wind energy project. Payback considers the initial investment costs and the resulting annual cash flow. The payback time (period) is the length of time needed before an investment makes enough to recoup the initial investment.

$$\text{SPS}=\frac{\sum(\text{investment}\ \ \text{cost}\,s)}{(\text{yearly}\ \ \text{benefits}-\text{yearly}\ \ \text{cost})} \tag{20}$$

However, the payback does not account for savings after the initial investment is paid back from the profits (cash flow) generated by the investment (project). This method is a "first cut" analysis to evaluate the viability of investment. It does not include anything about the longevity of the system.

- Initial rate of return: This is the opposite of simple payback period. The value makes the investment look too good.

$$\text{Initial rate of return}=\frac{(\text{yearly}\ \ \text{benefits}-\text{yearly}\ \ \text{cost})}{\sum(\mathit{investment}\ \ \text{cost})}*100\% \tag{21}$$

This initial rate of return acts as a minimum threshold indicator for the investment. If the internal rate of return is below this minimum threshold there is no need to proceed with the investment.

- Levelized cost of energy (LCOE): All the costs are added during a selected time period which is divided by units of energy. A net present value (NPV) calculation is performed and solved in such a way that for the value of the LCOE chosen, the project's NPV becomes zero. This means that the LCOE is the minimum price at which energy must be sold for an energy project to break even.

$$\text{LCOE}=\frac{\sum \cos ts\,/\,\text{no. years}}{annual\ yield(\text{kWh})} \qquad (22)$$

- Cash flow analysis: One of the most flexible and powerful way to analyze an energy investment is the cash-flow analysis. This technique easily accounts for complicating factors such as fuel escalation, tax-deductible interest, depreciation, periodic maintenance costs, and disposal or salvage value of the equipment at the end of its lifetime. In a cash flow analysis, rather than using increasingly complex formulas to characterize these factors, the results are computed numerically using a spreadsheet. Each row of the resulting table corresponds to 1 year of operation, and each column accounts for a contributing factor. Simple formulas in each cell of the table enable detailed information to be computed for each year along with very useful summations. Cash flow is always positive.

$$\sum cashflow_n=\sum benefits_n-\sum \cos ts_n \qquad (23)$$

where ***n*** is the number of years of operation from the start system operation.

- **Discounted cash flow (DCF):** DCF analysis uses future free cash flow projections and discounts them to arrive at a present value, which is used to evaluate the potential for investment. If the value arrived through DCF analysis is higher than the current cost of the investment, the opportunity may be a good one. The purpose of DCF analysis is to estimate the money one would receive from an investment and to adjust for the time value of money.

$$Discount\ cash\ flow_n=\frac{\sum benefits_n-\sum \cos ts_n}{(1+r)^n} \qquad (24)$$

r=the discount rate represents the interest rate used in calculating the present value of future cash flows and n (the years) from the system starts operation. The present worth factor in the above equation is given 1/(1+r)n. The value that is chosen for r shows that "weigh" the decision towards one option or another, so the basis for choosing the discount rate value must clearly be carefully evaluated. The discount rate depends on the cost of capital, including the balance between debt-financing and equity-financing, hence an assessment of the financial risk must be applied.

- Net present value (NPV): NPV compares the value of a dollar today to the value of that same dollar in the future, taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected because cash flows will also be negative. To calculate NPV; choose the time period for the project and sum all the discounted cash flows in that time period.

$$Discount\ cash\ flow_n=\frac{\sum benefits_n-\sum \cos ts_n}{(1+\text{i})^n}=NPV \qquad (25)$$

- Internal rate of return (IRR): This is perhaps the most persuasive measure of the value of a wind energy project. The IRR allows the energy investment to be directly compared with the return that might be obtained for any other competing investment. IRR is the discount rate that makes the NPV of the energy investment equal to zero. When the IRR is less than discount rate, it is a good indicator for the project.

$$\text{IRR}\rightarrow\text{NPV=0 i.e}\frac{\sum benefits_n-\sum \cos ts_n}{(1+\text{i})^n}=0 \qquad (26)$$

7. WIND TYPES AND MODELS CRITERIA SELECTION

The RETScreen Expert energy tool is still in a continuous improvements process to subjugate the barriers to clean energy technology implementation especially at the preliminary feasibility stage added the ability to rapidly analyze the feasibility of multiple wind power plant options, including assessing the output for various possible wind speeds at the site. We use this fast and strong feature never used before to assess potential of the wind farms with a mix of 16 different turbine types with different tower heights, rotor diameters and different wind resources located throughout the proposed site as it is shown in Table 1.

By selecting the site location on the map, RETScreen Expert model automatically generates data and information on several important climate indicators. First is analyzed the capacity and structure of 16 (Table 1) various wind types and then the most suitable scenario as matching the recommendations and global trends is selected. This selection is made taking into account both technical and economic context of various wind technologies, influenced from wind potential in the area. Methodology 2 to actualize the techno-economic analysis is chosen. Firstly, it is required to set into the model the values of the respective wind data in the area which may be represented as it is shown in the Figures 3-8. The selection of set of the turbines must meet optimum criteria simultaneously such as:

Table 1: Representation of the main's technical turbine datas selected for the proposed wind farm in Qafë-Thanë Pogradec, Albania

Turbine type and model	Power capacity (MW)	H (m)	D (m)	Swept area (m^2)
Vestas - V90	1.8	95	90	6361.73
Vestas - V90	2.0	105	90	6361.73
Vestas-V90	2.0	80	90	6361.73
Vestas-V90	3.0	90	90	6361.73
Vestas-V90	3.0	105	90	6361.73
W2E	2.5	117	100	7854
W2E	2.5	85	100	7854
W2E	2.5	98.2	103	8332.29
W2E	2.5	141	100	7854
Sinovel	1.5	80	82.9	5398
Sinovel	3.0	110	101.19	8042
Siemens an bonus	1.0	70	54.2	2307.22
Wind to energy	2.0	100	100	7854
Wind to energy	2.0	100	93	6793
Wind to energy	3.0	100	120	11310
Vensys	1.5	86	70	3848.45
Vensys	1.5	85	77	4656.63

- Generate high quality amount of 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.

This selection is made taking into account both technical and economic context of various wind technologies, influenced from wind potential in the area and financial parameters taken in consideration.

8. PROJECT COSTS CALCULATION AND ASSUMPTIONS

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 (Malka et al., 2020, Bebi et al., 2020). From (IRENA 2020) it is shown that turbine prices have fallen sharply in 2018, 53% compared to 2015 pushing forward investment of such technologies especially in countries with middle incomes, including Albania, as the initial cost has a very important impact on the results performed in financial analysis. Based on (Strategjia Kombëtare e Energjisë, 2018-2030) the total investment cost should be calculated within suggested interval of (1.3-1.65) m$/MW as our interest is too great due to drawing exact conclusions through simulations at the chosen applied sensitivity range of ±35%. The country/region weighted-average total installed cost for onshore wind in 2019 ranged from around (1055 to 2368) $/kW. In our case a total cost of around 1.3m $/MW is supposed.

As it shown in the study (Malka et al., 2020, Bebi et al., 2020) capacity factor increases from 20% in 1983 to 29% in 2017, with a 45% increase to increased performance of wind turbines using more advanced constructive technologies, increased tower height, increased rotor diameter and aerodynamic performance as well. Based on above mentioned data the selected wind turbines should comply with these criteria which are carefully considered in this work.

8.1. Operation and Management Costs

The operation and maintenance cost of Wind Power Plants is evaluated from 1.5% to 1.7% of the total initial cost, which is a recommended value provided in Strategjia Kombëtare e Energjisë (2018-2030), Maria Isabel Blanco (2009).

From the Table 2 the distribution of total investment cost for each components of the wind farm in terms of specific cost, $/kW is given. As it is shown in Table 2 the machine cost constitutes 75% of the total investment cost. The monetary values expected to be spent during the operational phase is calculated (refer Table 5). The expected specific cost of O&M results 15$/MWh of electricity exported to the grid is given per each subcategory such as salaries, maintenance, parts and others. 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 (David, 2009).

However, based on the annual range of O&M onshore wind costs in China, India and the rest of the world for the 448 project subset with O&M data given in (IRENA, 2020), the largest share of O&M costs is represented by maintenance operations, which have a weighted average of 67%, followed by salaries at 14% and materials at 7% (IRENA, 2018a; IRENA,2019).

Table 2: Costs breakdown and distribution (%) of the proposed wind farm in Qafë-Thanë Pogradec, Albania (Malka et al., 2020)

Components	Recommended distribution costs (%)	Supposed (%)	Cost (1,300 $/kW)
Turbine	65-80	75	975
Foundations	4-10	5	65
Elect. Installations	4-10	3.5	45.5
Grid connection	5-10	5	65
Road construction	1-5	3.0	39
Land acquisition	0-6	0	0
Permissions	0-2	1	13
Projection costs	3-5	3	39
Financial Costs	3-5	3	39
Infrastructure	1-5	1.5	19.5
Total		100	1,300

Table 3: Cost breakdown of O&M of the proposed wind farm in Qafë-Thanë, Pogradec, Albania (Malka et al., 2020)

Components	Recommended costs (%)	Accepted cost (%)	Annual cost ($)
Maintenance	65-80	75.0%	1441586
Salaries	4-10	7.0%	134548
Materials	4-10	8.0%	153769.2
Others	5-10	10.0%	192211.5
Total		100%	1922114.578

Table 4: Techno-economic parameters and assumptions considered for the proposed wind farm in Qafë-Thanë Pogradec, Albania.

Components	Value	Unit
Installed capacity	1→3	MW
Annual wind speed	6.0	m/s
Electricity export rate	76	$/MW
Investment cost	1,300	$/kW
Discount rate	5-7-11	%/year
Debt rate	70	%
Debt interest rate	3.0	%
Inflation rate	2.5	%
Debt term	15	Year
Reinvestment rate	5	%
GHG reduction credit rate	18	$
Turbine lifespan	25	Year
(O&M) cost	15	$/MWh
Land lease	Not applicable	Not applicable

For new project and country level data, the average O&M cost assumptions used for onshore wind LCOE calculations falls between (0.006-0.02) $/kWh (IRENA, 2020).

9. SIMULATION AND RESULTS

From Table 4 the main techno-economic parameters and assumptions used as primary indicators in the study are given. Power capacity range, annual wind speed, electricity export rate, and other financial parameters in the country context are accepted.

The technical aspects of turbine type selection directly affect the annual revenue generated by each turbine. In this study 16 different types and models of wind turbine are selected for further analyses providing the best capacity factor affecting on yearly energy production. We found that not only wind turbine type and model affect CF of the whole system but novel lies on **“flocking”** philosophy of different wind turbines into different groups and combinations so that the maximum energy output is achieved leading to lower simple pay-back periods (SPB) given from the simulation results in the graph given in Figure 11 below.

From the analysis performed in RETScreen Expert for a fixed installation cost (1.3 m$/MW), debt rate (70%) and discount rate r=(11)% scenario 6 results the most profitable scenario among 14 different scenarios as it is given in Table 5. For power capacity 27 MW the annual electricity generation results 61020 MWh.

Simulation and analyses are performed among 14 Scenarios created by combining 16 different types and models of wind turbines. As a result scenario 6 with a power capacity of 27 MW shows competiveness among the other scenarios producing a net annual of 61020 MWh.

Table 5: Presentations of wind farm scenario by turbine manufacture type and model

		VESTAS					W2E				Sinovel		SIEMENS	WIND TO ENERGY			Siemens	
	N (MW)	V90-1.8 MW - 95m	V90-2.0 MW - 105m	V90-2.0 MW - 80m	V90-3.0 MW - 90m	V90-3.0 MW - 105m	100/2.5 - 117 - 100m	100/2.5 - 85 - 100m	103/2.5 - 98.2 - 103m	100/2.5 - 141 - 100m	SL3000/100-110	SL1500/82 - 80m	AN BONUS 1 MW - 70m	100/2000 - 100 m	93/2000 - 100 m	120/3000 - 100 m	Venys70 - 85m	Venys77 - 85m
Scenario 1	27	0	2	0	0	0	0	0	0	0	0	0	0	4	3	3	0	0
Scenario 2	27.4	3	1	0	0	0	0	0	0	0	0	0	0	4	3	2	0	0
Scenario 3	27.6	2	2	0	0	0	0	0	0	0	0	0	0	4	3	2	0	0
Scenario 4	27.5	0	0	0	0	0	0	0	0	0	0	0	0	4	3	2	4	1
Scenario 5	27	0	0	0	0	0	0	0	0	0	0	0	7	4	3	2	0	0
Scenario 6	27	0	0	1	0	0	0	0	0	0	0	0	0	5	3	3	0	0
Scenario 7	27	0	1	1	0	0	0	0	0	0	0	0	0	4	3	3	0	0
Scenario 8	26	0	0	0	0	0	0	0	0	0	2	0	0	4	3	2	0	0
Scenario 9	26.8	1	0	0	0	0	2	0	0	0	0	0	0	4	3	2	0	0
Scenario 10	27	0	0	0	0	0	2	2	2	0	0	0	0	4	2	0	0	0
Scenario 11	27.5	0	0	0	0	0	5	2	2	2	0	0	0	0	0	0	0	0
Scenario 12	27.6	2	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scenario 13	27	0	0	0	0	0	0	0	0	0		18	0	0	0	0	0	0
Scenario 14	27.6	7	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0

From the analysis performed as a function of installation cost (1.3 m$/MW), debt rate (70%) and discount rate r=(11)%. scenario 6 results the most profitable scenario among 14 different scenarios chosen in the study. The SPB results 9.4 years and it is a really good period of time taking into the account the site wind potential.

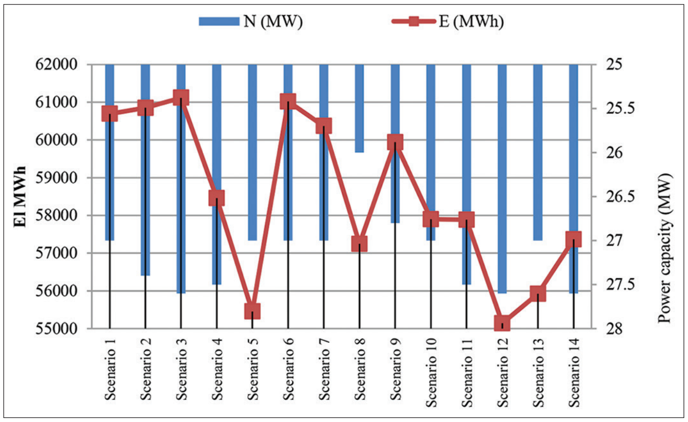
In Figure 12 the simple payback period for each scenario is calculated. From the analysis given as a function of installation cost (1.3m$/MW), debt rate (70%) and discount rate r=(11)%, scenario 6 results the most profitable scenario among 14 different scenarios chosen in the study. The SPB results 9.4 years (Figure 12).

The simple payback method is not a measure of how profitable one project is compared to another. Rather, it is a measure of time in the sense that it indicates how many years are required to recover the investment for one project compared to another. The simple payback should not be used as the primary indicator to evaluate a project. The calculation is based on pre-tax amounts and includes any initial cost incentives and grants.

In the Figure 13 the total investment costs is given. This represent the total incremental investment that must be made to bring the proposed case facility on line, before it begins to generate savings and/or revenue. The total initial costs represents the sum of the estimated feasibility study, development, engineering, power system, heating system and cooling system or energy efficiency measures and balance of system & miscellaneous costs and are inputs in the calculation of the simple payback, the net present value and the project equity and debt. From the simulation the total cost of scenario 8 is the lowest as the installed power capacity is 1 MW lower than scenario 6.

In figure 14 the electricity revenue and O&M cost for different scenarios is depicted. From the simulations among 14 different scenarios it is clearly shown that scenario 6 constituting of Vestas and Wind To Energy wind turbines models is chosen as it realize greater annual of electricity production. Based on the outputs

Figure 11: Electricity generation and power capacity under 14 different scenarios



depicted in the above graph a further detailed financial analyses is deeply performed in RETScreen Expert model.

The IRR, NPV and LCOE within a sensitivity range of ±35% are calculated. Inflows is compared against the present value of all cash outflows associated with the respective project investment cost.

The variation of NPV as a function debt rate within a sensitivity range of 35% for the total installed capacity 1.3 $m/MW and a discount rate r=5%, are depicted in the graphs in Figure 15 below. An inflation rate of 2.5% and a debt interest rate of 3% is assumed. Higher the debt rate, higher the NPV results. In our case two options 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. From the results shown in the graph in Figure 15 the impact of debt rate and installation cost extended on sensitivity range having a significantly important role. Consequently, the variation on both debt rate and installation cost must be addressed and fixed when facing real investment condition.

Figure 12: Simple pay back period (SPB) under 14 different scenarios

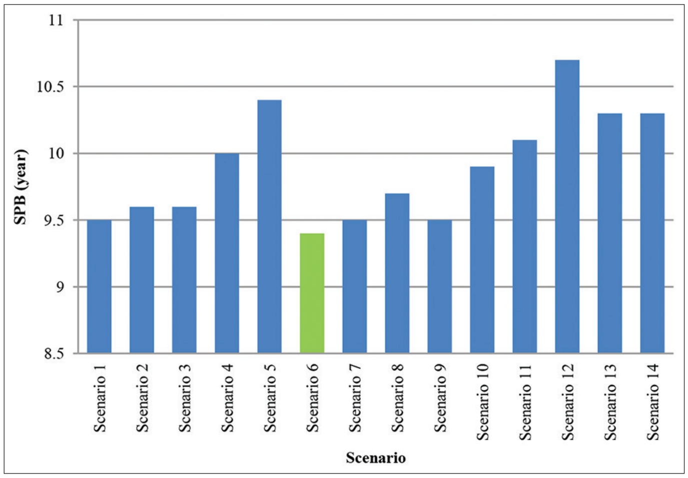
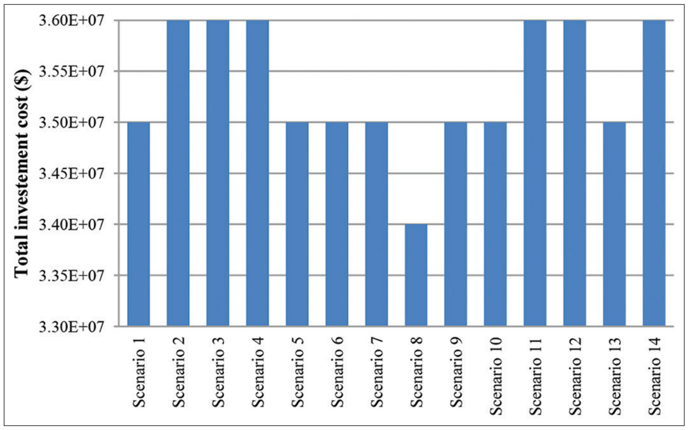


Figure 13: Total investment cost ($) for each scenario as a function of installation cost (1.3m$/MW) and debt rate (70%), r=(11)% inflation rate 2.5%.



From the simulation results executed in financial sheet the use of the debt ratio (%), which is the ratio of debt over the sum of the debt and the equity of a project and total investment over a sensitivity range of ±35% is given. The debt ratio reflects the financial leverage created for a project; the higher the debt ratio, the larger the financial leverage. In the graph in figure 15 for a total installation cost of 0.845$/MW, the difference in NPV value for 70% of debt rate results 20,489,472$ while the NPV for 94.5% of debt rate value results 21,241,115$ or 3.66% higher. Negative NPV values are observed if the total installation cost results 35% higher than the base installation price (1300$/MW). Based on the output of the study, the linear interpolation can be used as a good approximation by other researchers in the field.

So, for different electricity export rate ($/MW) the variation in NPV value referring 76($/MWh) of electricity export rate and 70% of debt rate value results 8,990,195$ while the NPV for 82.95% of debt rate value results 20,428,270$, 127.22% higher. Thus, for a fixed electricity export rate higher the debt rate higher the NPV results.

In the graph in figure 17 the NPV value of the proposed wind project as a function of electricity export rate ($/MWh) taking into

Figure 14: Electricity revenue ($) versus O&M cost as a function of installation cost (1.3m$/MW) and debt rate (70%), r=(11)% inflation rate 2.5% calculated for a fix electricity export rate of 76$/MWh

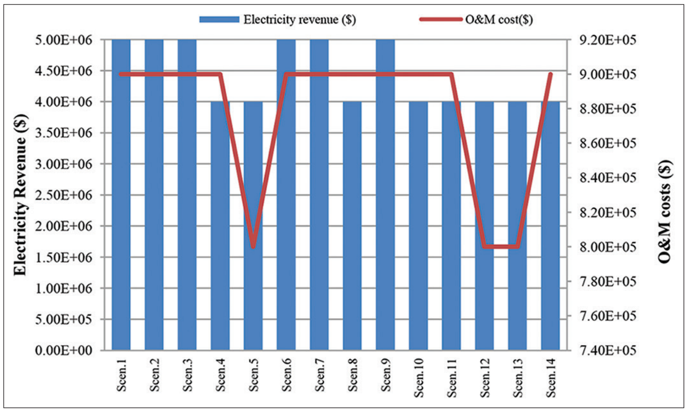
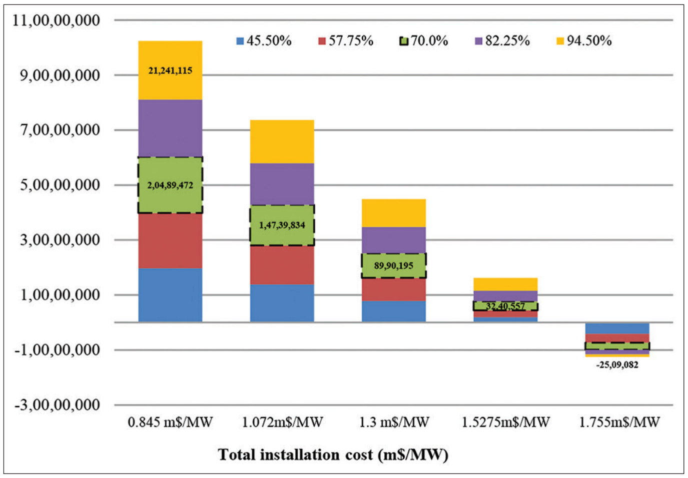


Figure 15: NPV comparison as a function of installation cost and debt rate (70%), r=(11)% performed over a sensitivity range of ±35%



consideration variation of debt interest rate(%)over a sensitivity range of ±35% for a fixed discount rate of 11% is given.

Apparently, for different electricity export rate ($/MW) the difference in NPV referring to all electricity export ($/MWh) and debt interest rate value of 1.95% results always negative. Thus, positive higher NPV values should have a debt interest rate greater than 1.95%.

In the graph in figure 18 the variation of NPV for three different levels of the discount rate (%) is depicted. The rates are enveloped in the detailed analyses to discount future cash flows in order to obtain the real present value. 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."

Figure 16: NPV comparison as a function of electricity export rate ($/MWh) and debt rate (70%), r=(11)% performed over a sensitivity range of ±35%

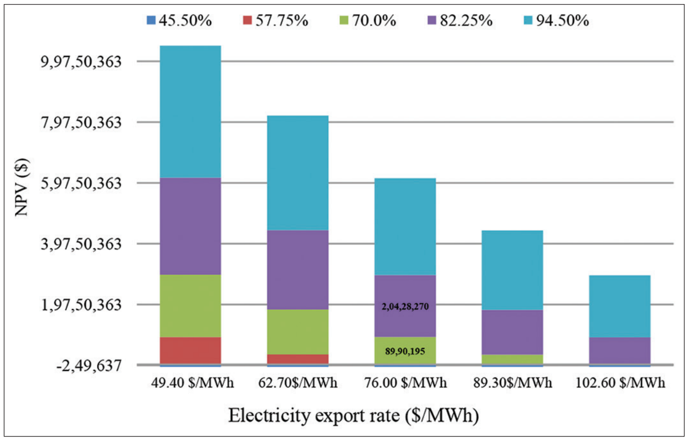


Figure 17: NPV variation as a function of electricity export rate and debt interest rate(%), for a given fixed discount rate r=(11)%; debt rate 70(%) performed over a sensitivity range of ±35%

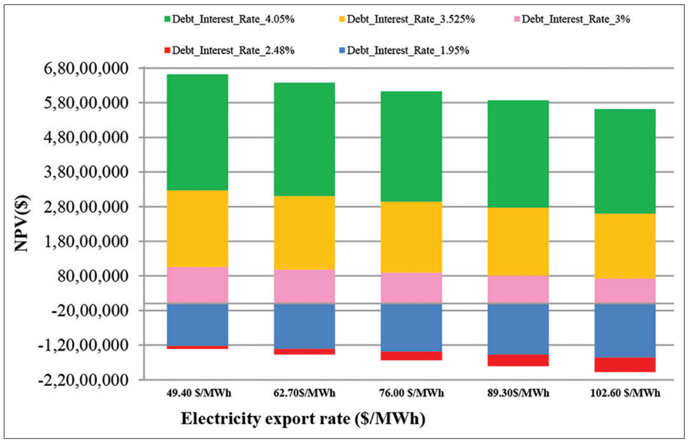
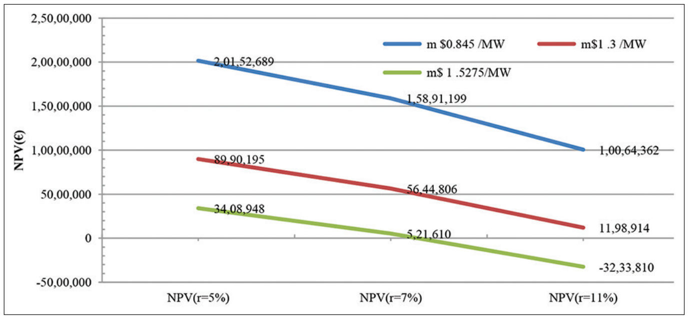


Figure 18: NPV variation for three different values of total investment (m$/MW) cost and discount rate, (r=5,7,11)%



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 (0.845÷1.5275) m$/MW an inflation rate of 2.5%, debt rate 70% and debt term 15 years 5% discount rate NPV at by a factor of 2 and by 3 for 1.5275 m$/MW case. By considering an increasing of the total installation unit cost from 0.845m$/MW to 1.3 m$/MW, the NPV decreases by 127% referring to the case of the discount rate 5%, 181.5% and 8 times less in the case of the discount rate 7% and 11% respectively. These two parameters are highly important variables which need to be analyses in detail.

In the graph in figure 19, the model calculates the pre-tax internal rate of return (IRR) on equity (%), which represents the true interest yield provided by the project equity over its life before income tax. It is calculated using the pre-tax yearly cash flows and the project life; referred to as the return on equity (ROE) or return on investment (ROI) or the time-adjusted rate of return. It is calculated by finding the discount rate that causes the net present value of the equity to be equal to zero.

Graph in the figure 19 represents the correlation of IRR as a function of total investment cost ($) and electricity export rate within a sensitivity range of ±35%, calculated for a debt rate of 70%, inflation rate 2.5%. The effect of discount rate variation on IRR is 0%. Lower the total installation cost of the wind farm higher the IRR results more feasible the project results. Negative IRR values are observed in the level of electricity export rate 49.4$/MWh in respect to the whole range of total investment cost.

In the graph in figure 20 the cost of electricity production (LCOE) per MWh which represents the electricity export rate required to have NPV equal to 0 is shown. But, the GHG reduction revenue, the customer premium income (rebate), the Other revenue (cost) and the Clean Energy (CE) production revenue are not included in this calculation.

In the graph in figure 21 B=C ratio as a function of discount rate and specific investments cost is given. Higher B-C ratio more profitable the project results. From the graph 21 results that B-C ratio is inversely proportional to the discount rate value, which means that lower the specific installation cost and discount rate higher the B-C ratio results, hence more likely the investments becomes.

From graph in figure 22 it is clearly seen that discount rate does not affect the SPB period. Referring to the unit installation cost of 1.3(m$/MW) it is concluded that SPB results 9.4 years. The influence of discount rate on the simple payback period (SPB) for the three different unit installation cost taken in the study is negligible.

Figure 19: IRR variation as a function of total investment cost($) and electricity export rate ($/MWh) within a sensitivity range of±35%, r=(11)%

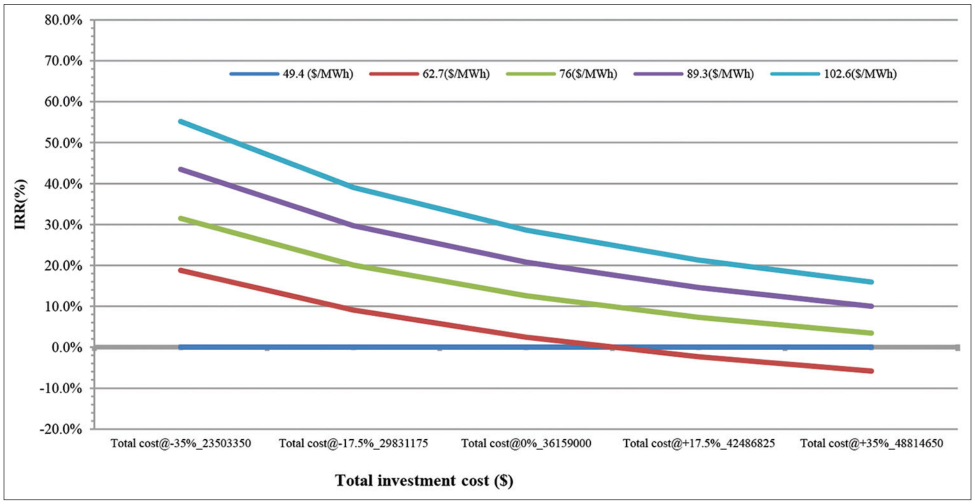


Figure 20: LCOE as a function of discount rate(r=5,7,11)% applied for three total investment levels

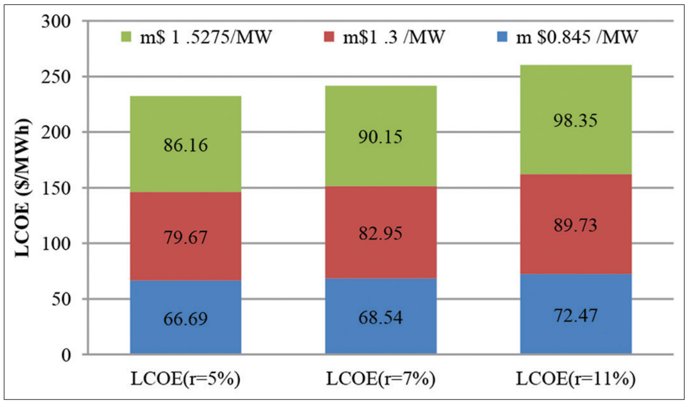
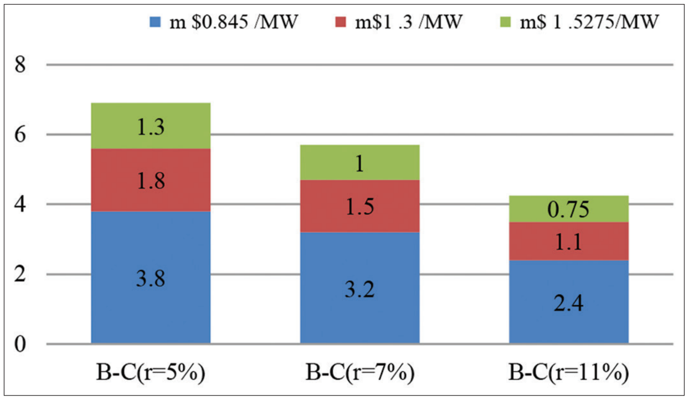


Figure 21: Graphical representation of B-C as a function of discount rate (r= 5,7,11) % applied for three total investment levels

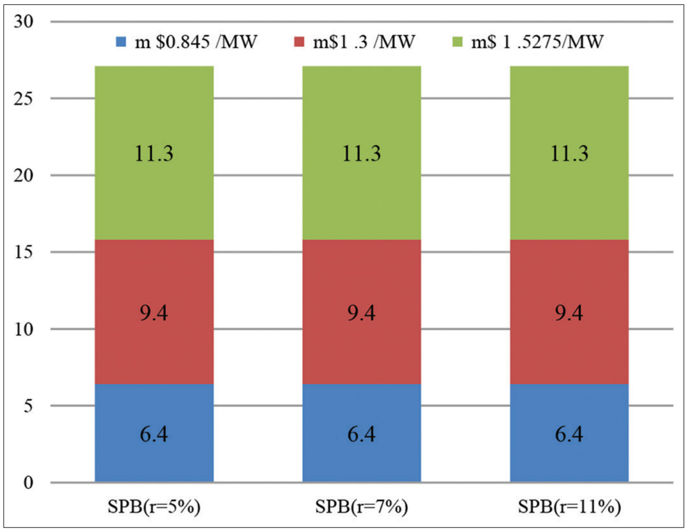


Finally, from the analysis performed and depicted in two above (graph 21 and 22) it is shown that B/C ratio is inversely proportional to the unit price of the investment, while SBP is proportional.

9.1. Risk Analyses

The risk analysis for this project following a Monte Carlo simulation including up to 1500 possible combinations of input variables, hence resulting in 1500 values of (pre) and after-tax IRR-equity, (pre) and after-tax IRR-assets, equity payback, Net Present Value (NPV) or energy production cost is performed. The risk analysis gives us the possibility to assess if the variability of the financial indicator is acceptable, or not, by looking at the distribution of the possible outcomes. The sensitivity range in this simulation is accepted ±35%. The key parameters to perform risk analysis is given in Table 5.

Figure 22: Graphical representation of SPB and Equity payback as a function of discount rate, r=(5,7,11)% applied for three different of total unit investment costs.



In the graph in figure 23 the relative contribution of the uncertainty in each key parameter to the variability of the financial indicator is presented. The horizontal axis at the bottom of the graph in figure 23 does not have any units, but rather presents a relative indication of the strength of the contribution of each parameter considered in the study.

The longer the horizontal bar, for a given input parameter, the greater is the impact of the input parameter on the variability of the financial indicator.

Figure 23: The impact graph results applied for 1500 possible combination of parameters at a 5% level of risk for the proposed wind farm in Qafë-Thanë Pogradec, Albania (Malka et al., 2020)

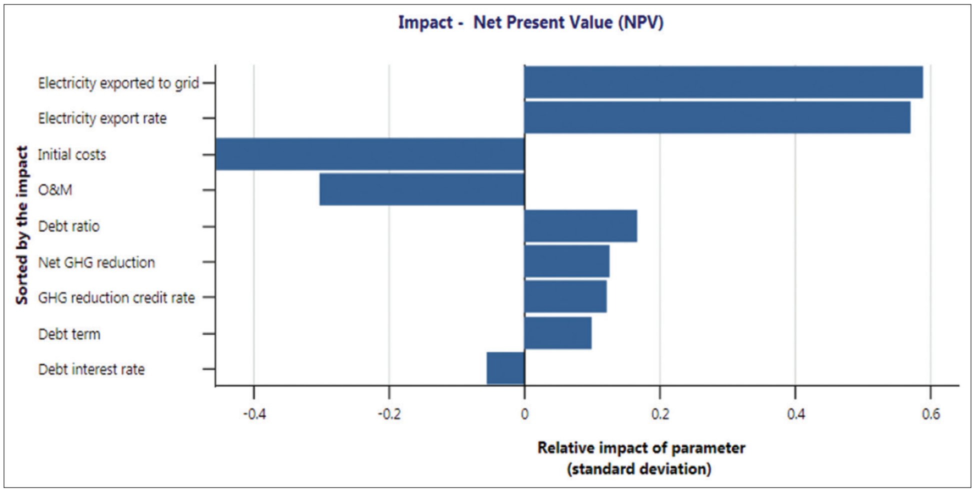


Table 6: Risk analysis reflecting the different key parameters for the proposed wind farm in Qafë-Thanë Pogradec, Albania.

Perform analysis on	NPV		Range (±)	Min	Max
Parameter	Unit	Value			
Initial costs	$	42301500	35%	27495975	57107025
O&M	$	15	35%	9.75	20.25
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
Debt rate	%	70	35%	45.5	94.5
GHG reduction credit rate		18	$/t CO_2	11.7	24.3

There is a positive relationship between an input parameter and the financial indicator when an increase in the value of that parameter results in an increase in the value of the financial indicator. In our case, there is identified a negative relationship between initial costs, O&M costs; debt interest rate and the Net Present Value (NPV), since increasing the initial costs will decrease the NPV. The impact of electricity exported to the grid on NPV results positive and has the highest weight among parameters.

9.2. Results and Discussion

After studying the wind potential in Qafë-Thanë, Pogradec District, it is possible envisioned a wind farm with installed power 27 MW. In order to make a financial estimate 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 1300 $/kW, the total installed cost of investment results $42301500. If the installation price reduces by 35% the total investment cost results $27495975 (the minimum expected investment) otherwise the price is increased by 35% than a maximum investment sum will result $57107025.

Based on literature reviews, survey responses, technology deployment 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 selling price by the proposed wind farm is assumed to be delivered at least at a 76 $/MWh during the expected lifetime of the proposed project if 18$/t CO_2 GHG reduction credit rate is assumed. Feed-in Tariffs as a Policy Instrument for Promoting Renewable Energies and Green Economies in Developing Countries is given (UNEP Study. (2012)).

The internal rate of return of this wind power project for the 25 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; Bebi et al., 2020). In our case this indicator varies at a range of 0.75 and 3.8. The result from the estimated LCOE for the supposed wind farm using a discount rate of 5% and 11%, results 0.0862 and 0.0984$/kWh, higher compared to the 2016 LCOE estimation for Europe which was 0.08$/kWh (IRENA, 2018). Based on the economic analysis of this study, it is shown 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, will help investors and will open competition for large investments in the field of RES (Tisdale, M., Grau, T., Neuhoff, K. (2014)). Several cost reduction opportunities are discussed to guide the development of future energy conversion, especially from emerging renewable energy resources (T.T.D.Tran, (2018)).

RETScreen Expert, an advanced computer software, executing excellent behavior regards to the preparation of pre-feasibility studies in RES projects with a high accuracy level.

Firstly, the proposed wind farm location is the most important aspect. Hence the results shows that the turbines for low turbulent wind sites should have a bigger diameter rotors and hub heights too.

Secondly, minimizing cost is the next most important design criteria which must be a matter of optimization criteria.

The results of the study lead to the conclusion that the cost is a very critical factor that restrains the wind power generation plants.

If the lower bond of the total cost given in (Strategjia Kombëtare e Energjisë, 2018-2030) lower level of total cost should be reduced by an additional 17.5% up to 35%, then it could be very competitive under Albanian wind potential condition.

The selling price of electricity, discussed in details in the financial analysis is assumed 76 $/MWh. Considering a sensitivity range of ±35% this price must serve as the low threshold for a total installation cost between the range of (0.845-1.3) m$/MW.

This work will support our last study that bonus factor should be adjusted at least to 1.4. The most important indicators and the feasibility zone such as (NPV), (IRR) and (SPB) are calculated. As a conclusion this study will serve starting point for possible investment resolving the most critical issue related to the exact LCOE calculation under different financial and scenarios paving the energy investor's way to invest in RES technologies.

10. CONCLUSION

This article used a case study of a land-based wind farm project of 27 MW to develop economic-evaluation methods that are helpful in determining whether this renewable energy project is economically efficient.

This assessment is processed through RETScreen Expert energy model which combines 14 different scenario among 16 types and models of wind turbines. From the outputs of the study we highlight that scenario 6 results the most favorable total with capacity of 27 MW generating an annual electricity of 61 GWh.

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 generating an annual electricity of 60GWh, equivalent to 0.8% contribution referring the total electricity consumption in our country (ERE, 2019) making 0.24% to the final energy consumption. If the supposed capacity of 27MW will be installed than 60GWh of electricity will be produced and a net reduction of GHG 57436.3223t CO_2/year which is equivalent to 5282.6489 hectares of forest absorbing carbon is provided.

While, the purchasing price of electricity generated from renewable energy sources especially from wind in the Hungarian Power Exchange for 2019 was 51$/MWh (Ag, Axpo Trading. (2019), Malka et al. [2020]) so that with this price is 42 % lower than LCOE calculated in the study (refer graph in Figure 20) means that the bonus factor should be corrected at least at 1.42.

Furthermore, the outputs of the study strongly support the results given in the previous study (Malka et al., 2020) but a GHG reduction credit rate of $18/(t CO_2) should be applied. This is a national challenge driven by global policy makers in the respective field so that the solutions needed are complex and expensive. If our county, Albania will work alone than the fostering of RES will be difficult and the flexibility of the power sector would not be achieved. From (Eurostat, 2020) the border countries such as Kosovo, North Macedonia and Greece are characterized high share rates of fossil-fuel based power system then Albania can be a good exporter of electricity maximizing the benefits and will open the investment competition of wind farms. The proposed measure includes the need to further unbundle and liberalize the energy market following the adoption of the required legal basis, including GHG credits.

In Albania, especially in Vlora, where there is a 98 MW gas-fired power plant, and putting it into operation, I think it would pave the way for the construction of a wind farm in Karaburun area by installing a capacity of 500 MW. The synergic combination WPP and gas PP with provide at any time a net power generation of 100 MWh. The same scenario should be implemented in Korca to support wind farm investment of 164MW studied in (Malka L., Konomi I., Gjeta A., et al. (2020). The integration of a mix gas-fired power plant supporting RES and optimizing energy sector in Albania will be another issue I will develop in my future work.

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