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# Technical and Economical Aspects of Wind Energy Application in Azerbaijan

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**Abstract** The paper concerns to the economical aspects of wind energy application in Azerbaijan. Economical effectiveness of wind energy plants transforming wind energy into electricity have been calculated. Electricity cost obtained from the wind energy plants being in exploitation, payback duration of the plants, expenditures spent to the exploitation and total economical profit were determined. Finally dependence of wind energy plant payback duration on some parameters were calculated

**Keywords** Wind energy, Wind speed, Payback duration, Economical calculation

## 1. Introduction

Among the alternative energy sources the wide applied one is wind energy. According to the high potential, technical and economical effectiveness wind energy is advisable. Transformation of wind energy into electricity is realized by the wind energy plants. Total amount generated in wind energy plants depends on directly on wind speed. While wind speed being 5-25 m/sec (3-9 points by Buford scale) these plants are working effectively. In calm or less windy air electricity supply is provided on the existing power stations. At the result of the long term meteorological measurements the territories with strong and periodic winds were determined where wind energy plants installation is realized. Depending on the height the wind speed increases, therefore wind energy plants are to be located on the highest places. Wind energy plants working in parallel on the sea sides and in the sea have great effectiveness. In Europe wind energy plants mainly are being settled on Baltic, The North sea and The Atlantic ocean costs. In the far regions where there is few energy resources energy provision depends entirely on energy transfers transportation. Wind plants are also used in agriculture field and cattle husbandry for water provision systems. This method is utilized in desalination process and soils, meliorations. The persons who are against the wind energy development think that wind energy plant and energy transferring lines mutilate the environmental state. Noise of the plant is heard in kilometers distance far from, obstacles appear in television and telephone lines. That's why in the west Europe wind energy plants have been mostly built far from sea sides very much.

Beside technical, energy parameters of wind energy plant economical effectiveness have to be defined. Because economical profit obtained from wind energy is compared with the traditional energy. The price of electricity generated from wind is lower than before, again that's sufficient. In inspite of these wind energy application validates especially in the zones with high speed. The plants transfereing wind energy into electricity mainly possess horizontal axes, partly few usable plants have vertical axes. Effeciency of the present wind plants is about 45%. Due to the wind energy plants exploitation among the first five countries are (2011) China (41800MW), USA(40200 MW), Germany (27214 MW), Ispania (20676 MW), India (13064 MW). Effectiveness of wind energy depends on wind speed. Taking into considration connection the electricity line to the common source charge should be calculated in advance. Wind speed isn't stable. The loading may be minimum and maximum in the common source.

Total kinetic energy of the wind energy in the Earth is approximately 0,7·1021Coul[1]. But the great part of this energy stays above the oceans. Also in the plains no surrounded by any forest wind speed is enough higher. Thus, winds blowing in such geographical location are periodical, that's important for wind energy plants to work effectively.

## 2. Wind Power Calculation

Wind flow power blowing via unit square $S_w$ is determined by this formula.

$$S_w = \frac{W_w}{t} = \frac{m \cdot V^2 r}{2t} = \frac{F_0 V \cdot V^2}{2} = kV^3 \qquad (1)$$

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Here, $W_w$ -kinetic energy of wind, Coul;

$t$ - wind blowing time, sec;

$m$ - during $t$ air flow passing via $F_0$ square, kg;

$r$ - air density, kg/m3; $r = 1,3kg / m^3$;

$V$ - wind speed, m/sec;

$k$ - wind energy coefficient, kg/m; $k = 0,65kg / m$;

So, wind strength is adequate with wind speed in third degree and for estimation of this strength necessary information on wind speed is demandable. For periodical measurement of wind speed in Azerbaijan weather stations are acting[2,3]. In this stations wind speed is measured in 10 m height from the earth surface. Taking into considration wind plants to be in several heights, on the very point wind speed is determined by the following empric formula.

$$V_h - V \cdot 0,1hb \qquad (2)$$

Here, $V_h$ - wind speed in h height, m/sec;

$V$ - wind speed due to weather stations, m/sec;

$h$ - height in which wind wheel is situated, m;

$b$ -empiric coefficient.

These parameters for plains consists of $b = 0,14 - 0,16$ [4].

Average annual wind speed amount in Azerbaijan Republic was given below[5].

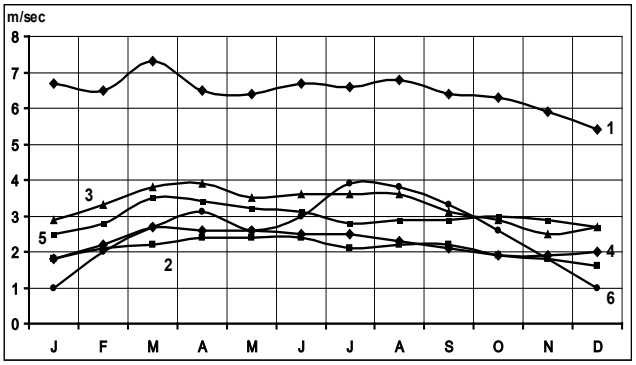


**Figure 1.** Dependence of average annual wind speed in some regions and cities of Azerbaijan (1- Baku, 2- Khachmaz, 3-Ganja, 4-Shirvan, 5-Lankaran, 6-Nakhchivan) on the months of year

In the figure shows that the high potential Azerbaijan in Baku city. The average wind speed for the Baku city is 6.5 - 7 meters per second. In this purpose the main parameters studied of the wind in Baku. In below wind measurements at meteo tower with a height of 80 meters[6,7].

## 3. Wind and Energy Rose

The following graphic shows the wind and energy roses as well as the fitted Weibull distribution for MT met mast at 40 m measurement height. The tab file which has been used to perform this calculus has been calculated.

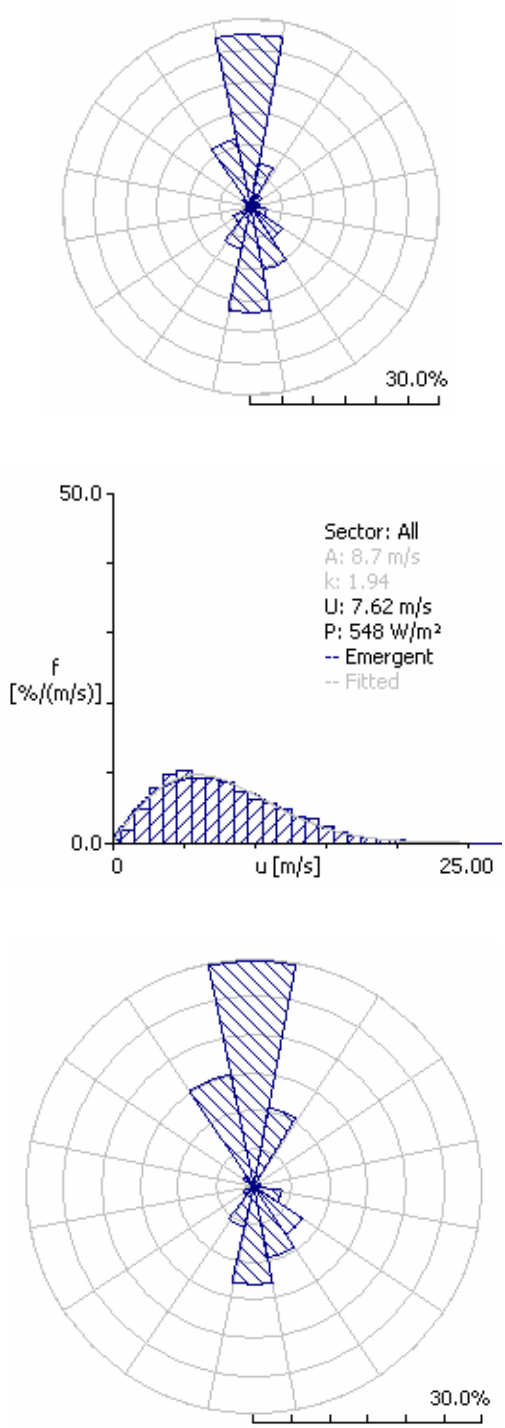


**Figure 2.** Wind rose, fitted distribution and energy rose at meteo tower met mast at 40 m measurement height during the period (August 2011 – May 2012)

## 4. Turbulence Intensity

Next graphic shows the turbulence intensity at meteo tower met mast used for the wind farm study. This graphic has been calculated with the wind data at each measurement height during its corresponding period (August 2011 – May 2012)[6].

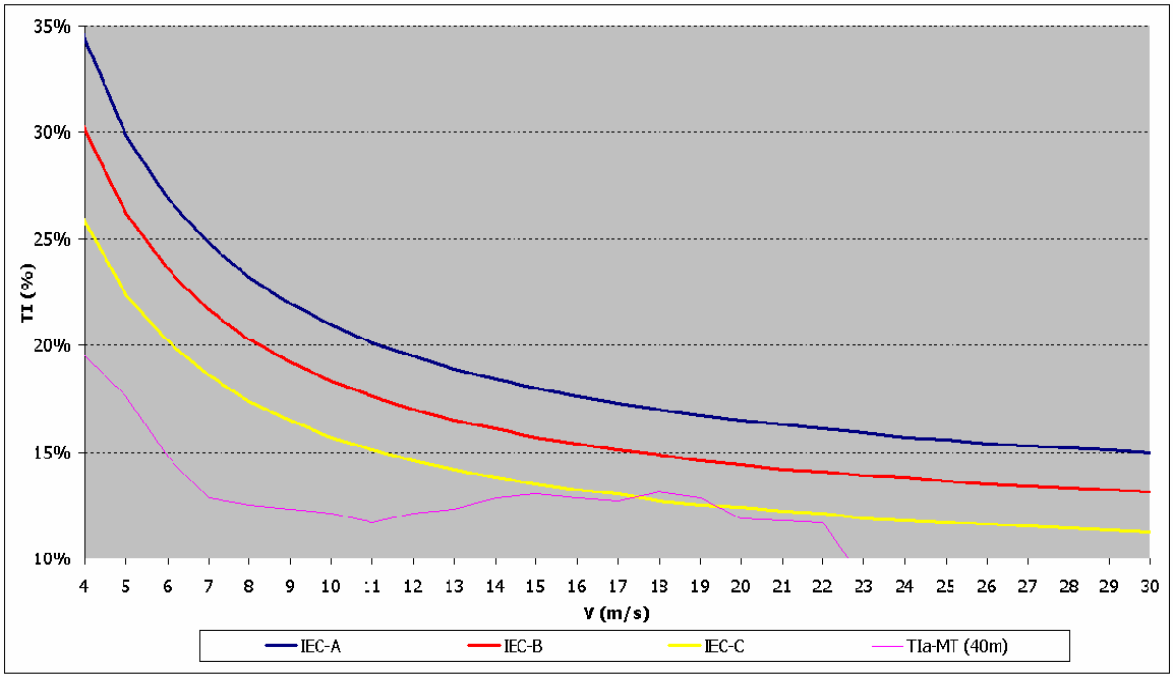


**Figure 3.** Turbulence Intensity at meteo tower met mast at BAKU

As the number of ten-minute data from bin higher than 22m/s at meteo tower met mast are low (less than 30 ten minute average records), turbulence intensity of those bins has not been considered representative and it has not been taken into account in the calculations.

As it can be observed in previous graphic, turbulence intensity measured at meteo tower met mast at 40m measurement heights is under the limits specified by IEC-B subclass, according to IEC 61400-1 Ed3 Standard [8,9,10,11].

TI15 value at meteo tower met mast at 40 m in the reference period 26/07/11 - 21/05/12 is 12.3%, (TI15: Weighted average value considered for the turbulence intensity from 10 m/s up to cut-out wind speed).

As the measurement period of meteo tower met mast is less than one year, the value of turbulence intensity of the met mast has not been considered as reliable and it must be checked again when there is a complete year of measured data.

## 5. Economical Calculation of Wind Energy

During calculating economical effeciency these parameters should be taken into considration[12,13]:

- Wind energy potential of the concret region;
- Price of wind plant and its departures;
- Transport expenditures in order to carry for wind plant building;
- Building expenses of wind plant;
- Service expenses for wind;
- Purchase price of electricity generated from wind.

Cost of electricity generated from wind plant and specific cost of defined power deals with plant service duration.

$$D = \frac{N_p \cdot r_e \cdot C + i_{ex} \cdot T_s}{E \cdot T_s} \tag{4}$$

Payback is calculated by the following formula.

$$T_{pb} = \frac{N_p \cdot r_e \cdot C}{E \cdot S_e \cdot i_{ex}} \tag{5}$$

Here, $N_p \cdot r_e \cdot C$ - is total cost of wind energy plant (capital costs), $S_e$ - at present electricity cost generated by the traditional fuels, $E = \triangleleft N \triangleright T$ - annual electricity generated from wind $kW \cdot hour / year$, $i_{ex}$ -exploitation costs USD/year.

Power coefficient of wind energy plant K is suitable to exploitation costs, then

$$i_{ex} = \gamma N_p r_e C \tag{6}$$

The cost of electricity is determined so:

$$D = \frac{r_e \cdot C \cdot (1 + \gamma \cdot T_s)}{K \cdot T \cdot T_s} \tag{7}$$

Payback duration of wind energy plant is determined:

$$T_{pb} = \frac{r_e \cdot C}{T \cdot K \cdot S_e - \gamma \cdot r_e \cdot C} \tag{8}$$

Dependance of wind plant payback duration $T_{pb}$ on the determined usage power coefficient - was given at the table 1.

As seen from the table economical indexes determining

wind energy plant effectiveness depends on traditional electricity energy cost seriously.

**Table 1.** Payback duration of wind energy plant

| **Electricity cost,** USD/kW/hour | **Usage coefficient on defined power, K, %** | | | | |
|---|---|---|---|---|---|
| | **100** | **80** | **60** | **40** | **20** |
| 0,02 | 8,85 | | | | |
| 0,04 | 2,45 | 4,83 | 8,91 | | |
| 0,06 | 2,09 | 3,66 | 4,98 | 8,01 | 17,74 |
| 0,08 | 1,48 | 1,13 | 2,31 | 5,65 | 9,35 |
| 0,10 | 1,27 | 1,01 | 2,09 | 3,22 | 6,84 |

Economical benefit of wind energy plant utilization is defined so:

$$B = (T_s - T_{pb}) \cdot M(E \cdot D_t - i_{ex}) T_s \cdot Q(A_{gl} - D_t) \quad (9)$$

Here, $M$ – total amount of wind plant, $D_t$ - present price of electricity obtaind from the traditional fuel (tariff), $Q$ - futility in electricity generation on the region, $A_{gl}$ - especial cost of loss in electricity generation.

## 6. Results

On the calculations for determination of economical effectiveness of wind energy plant I hav ecome into conclusion that howmuch electricity generated is sold expensively, wind energy plant can validate itself so much. Almost exploitation of wind energy plants in the regions with high potential may be too effective. Thus, in such regions utilization of wind energy plants with great power is corresponding.

## 7. Conclusions

Conducted research shows that wind power in Azerbaijan is very efficient from a technical and economic side. High technical and economic potential of wind energy in Azerbaijan allows development of renewable energy sector in Azerbaijan republic.

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