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# Simulation of the Influence of Temperature on the Resultant Wind Power in Samawa City – Iraq

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## Abstract

The assessment of the percentage of loss in annual rates of wind power by influence of temperature on the in Samawa city-Southern Iraq is investigated for five years (2012-2016). The study illustrates that the percentage of loss in annual rates of wind power range between 4.7% at the study period 2013 and 5.8% at the study period 2016. **Objectives**: In the present study, the influence of temperature on the resultant wind power in Samawa city- Southern Iraq is studied. **Methodology**: Data of wind speed, and temperature are measured at an altitude of 11 meters (altitude of meteorological Station of AL. Samawa) for five years (2012-2016). This data used as input to a software computer program that was prepared for this study to solve the set of equations in section 2 for simulates the temperature effect on extracted wind power. **Finding/Improvement:** The study illustrates that the percentage of loss in annual rates of wind power range between minimum value 4.7% at the study period 2013 and maximum value 5.8% at the study period 2016. The study attributes that to the loss in the air density, and illustrates that the percentage of loss in annual rates of air density ranges between minimum value 4.7% at the study period 2013 and maximum value 5.8% at the study period 2016. The amount of percentage of loss in annual rates of wind power reduces with the increase in height. **Application**: Production of electricity from wind energy as renewable energy resources.

**Keywords:** Iraq, Physics Energy, Renewable Energy, Wind Power

## 1. Introduction

Energy is defined as the capacity to do work. It is available to use in various forms and from many different sources[1]. Primarily the energy sources can be divided into non-renewable and renewable energy sources[2]. Non-renewable energy is the energy type which is obtained from static stores of energy that remain underground unless released by human intervention. This type of energy can be classified into nuclear fuels and the fossil fuels of coal, oil, and natural gas[3]. In recent years the focus has been on renewable energy sources very has been clear[4]. The world's energy supply is largely based on fossil fuels and nuclear power. These sources of energy will not last forever and have proved to be contributors to our environmental problems. Due to population growth in Iraq, there is a demand for increased energy consumption.

Iraq has promising renewable sources of energy characterized by economical and environmentally friendly sources, such as wind and solar. This study deals with the influence of temperature on the resultant wind power as a renewable energy for electricity production in Samawa city, situated in southern Iraq on latitudes (31.316) and longitude (45.283). The data of wind speed, and temper-

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ature are measured at an altitude of 11 meters (altitude of the anemometer of meteorological station of Samawa city).

## 2. Theory

Can be expressing the mechanical power which is extracted from wind turbine and estimated by taking the derivative of the kinetic energy of the wind by the equation[5,6]:

$$P=0.5C_p\rho Av^3 \quad (1)$$

where, $C_p$ the power coefficient representing the overall efficiency, $A=0.5\Pi r^2$ the swept area of turbine blades (airflow cross section) in ( $m^2$), $r$ is the rotor radius, ($\rho$) is the air density (1.255 $kg/m^3$), ($v$ )is the wind speed in (m/s). The relationship between temperature and pressure can be expressed by Poisson equation[7,8]:

$$(T_1/T_2)=(P_1/P_2)^{R/C_p} \quad (2)$$

where, $R/C_p=0.286$, is the constant –pressure specific heat of air, $T_1$ and $P_1$ are temperature and the pressure at site(1), $T_2$ and $P_2$ are the temperature and pressure at site(2). The equation which predicts the temperature as a function of altitude is expressed as the following[9]:

$$T(z) = T_g-R_a(z-z_g) \quad (3)$$

where, T(z) the temperature at altitude z in meter above sea level, $T_g$ is the temperature at ground level $Z_g$, and $R_a$ is the temperature laps rate (0.0065$C^0m^{-1}$), $(z-z_g)$ is the altitude above ground level. Air density can be determined in term of pressure and temperature by the following equation:

$$\rho=(P_0/RT) \exp(-Gz/RT) \quad (4)$$

where, $P_0$ is the std. sea level atmosphere pressure (101325 Pascal), G is the gravitational constant (9.8 m/s), and R is the universal gas constant for dry air (287.05$JK_g^{-1}K^{-1}$). The annual mean wind speed is given as follows[5]:

$$v_m=(1/8760)\int_{0}^{\infty}hv\,dv \quad (5)$$

The speed every hour averaged over the day, which in turn was averaged over the month and over the year, the average was done as follows[5,10]:

$$v_{av}=(1/n)\sum_{i=1}^{i=n}v_i \quad (6)$$

where, n is the number of observations in the average period, $v_i$ is the wind speed at the observation time. The wind power is proportional to the speed cube, and collected over the year (equivalent to the integral of ($hv^3$ dv, therefore, this defines the root mean cube (rmc)speed in the manner similar to the root mean square (rms) value[10]:

$$v_{rmc}=(1/8760)^{1/3}\int_{0}^{\infty}(hv^3dv)^{1/2}$$

$$v_{rmc}=(1/n)^{1/3}\sum_{i=1}^{i=n}v_i^3 \quad (7)$$

The rate of wind speed as a function of earth surface roughness or terrain characteristic of wind speed is given by the following expression[11,12]:

$$(v/v_i) = (H/H_i)^{\alpha} \quad (8)$$

where, $v$ is the wind speed at height H,$v_i$ is the nominal wind speed at height $H_i$, $\alpha$ is the fraction coefficient calculated by the following equation[11–14]:

$$\alpha= (0.37-0.088\ln(v_i))/(1-0.088\ln(H_i)) \quad (9)$$

## 3. Results and Discussion

A software computer program has been prepared for this study. All equations mentioned in section 2 have been solved by that program. The measured monthly data of wind speed, temperature [5] have been used as input into the program, hence the values of $\rho$=1.225Kg/

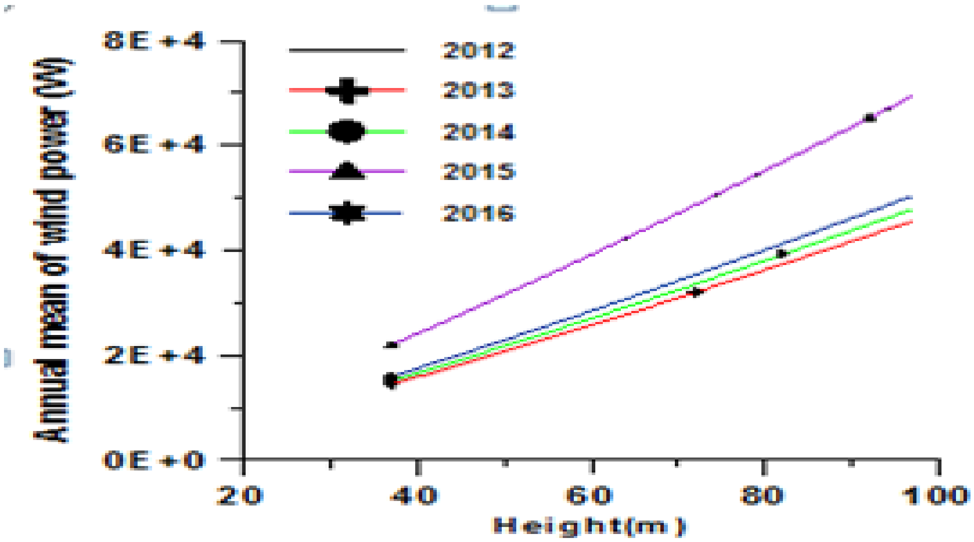


**Figure 1.** The annual mean of mind power as a function of height without temperature effect.

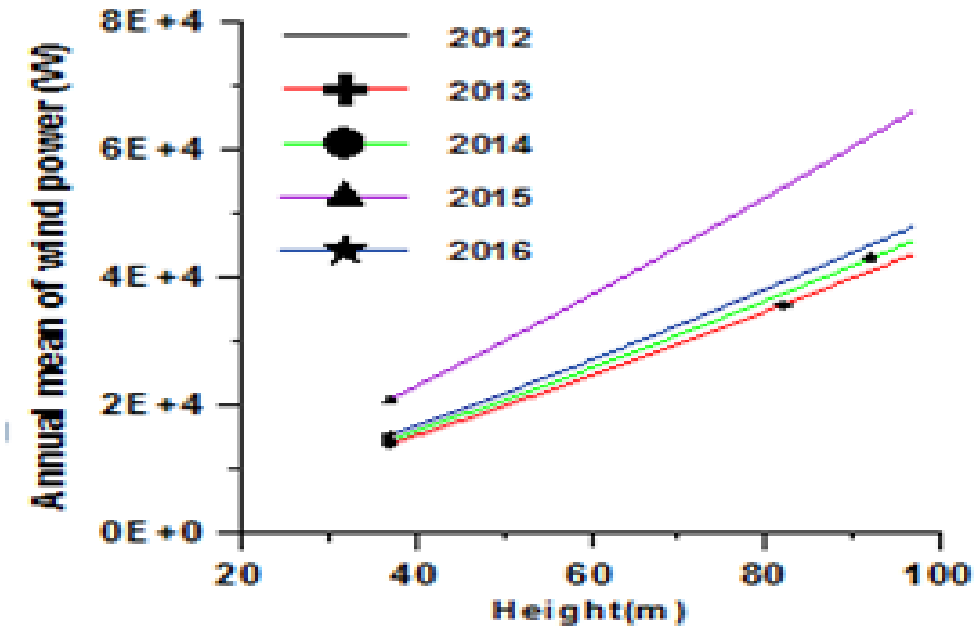


**Figure 2.** The annual mean of wind power as a function of height with temperature effect.

$m^3$, $C_p$=0.5, $P_0$=101325$p_a$, swept diameter r=10m, α=0.323,0.337,0.323,0.333, for study period(2012-2016) respectively[14].

Figures 1 and 2 show the comparison between the behaviour of the annual rates of wind power as a function of height. Figure 2 Shows those values of annual rate of power lowered due to temperature effect in term of height. The study attributes this lowering to the direct influence of temperature on air density, it appears from inverse relation as shown in Figures 3 and 4. Figures 5 and 6 also show the comparison between the values of annual rates of air density dependent on temperature influence for the period of the study as a function of altitude.

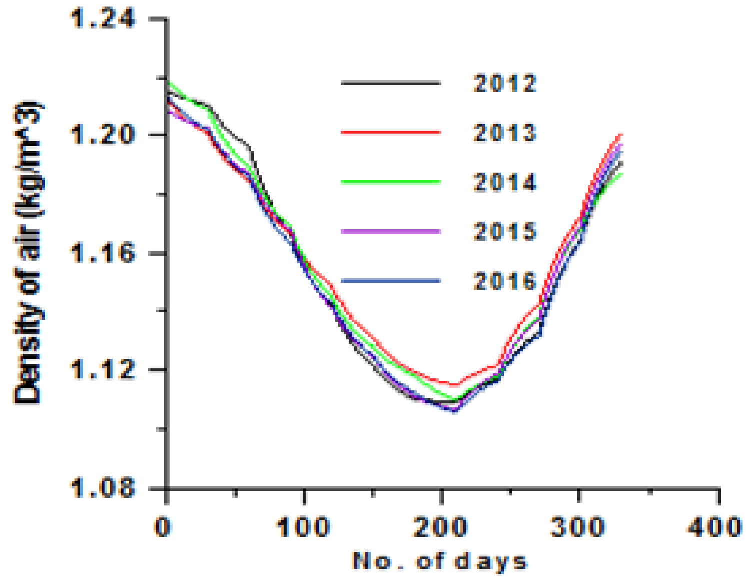


**Figure 3.** The daily air of density distribution for period (2012-2016).

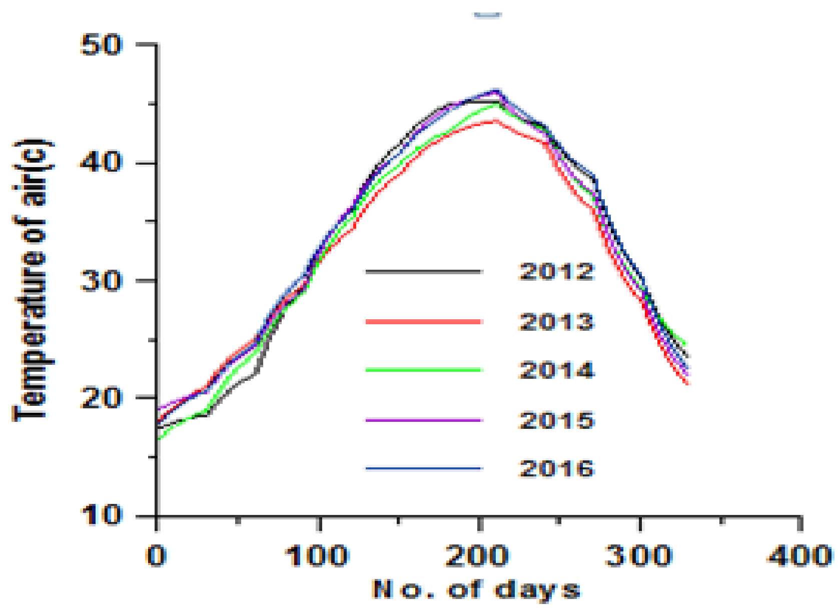


**Figure 4.** The daily air temperature distribution for period (2012-2016).

Figure 6 represents the case which does not consider temperature impact, where a lowering in values of annual rate of air density with altitude increase is observed. Also Figure 6 represents the influence of temperature on the annual values rates of air density for the study period and heights recommended, where a behaviour, different from the one indicated in Figure 5 is noticed. An increase in the annual values rates of air density is seen. The study attributes this increase to a double influence on air density relying on heights; the first is the influence of air pressure and the second is temperature influence, where pressure and temperature decrease, whenever height the increases as shown in Figures 7 and 8. The reduction in air pressure

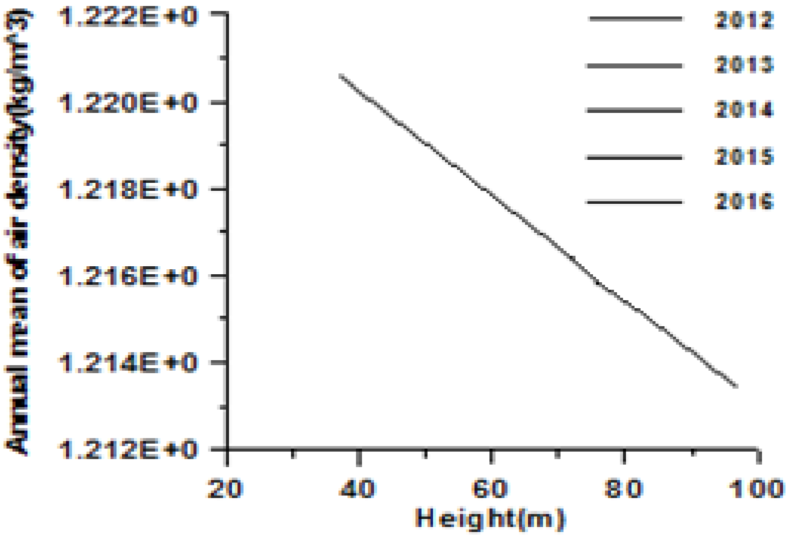


**Figure 5.** Annual mean of air density as a function of height without temperature effect.

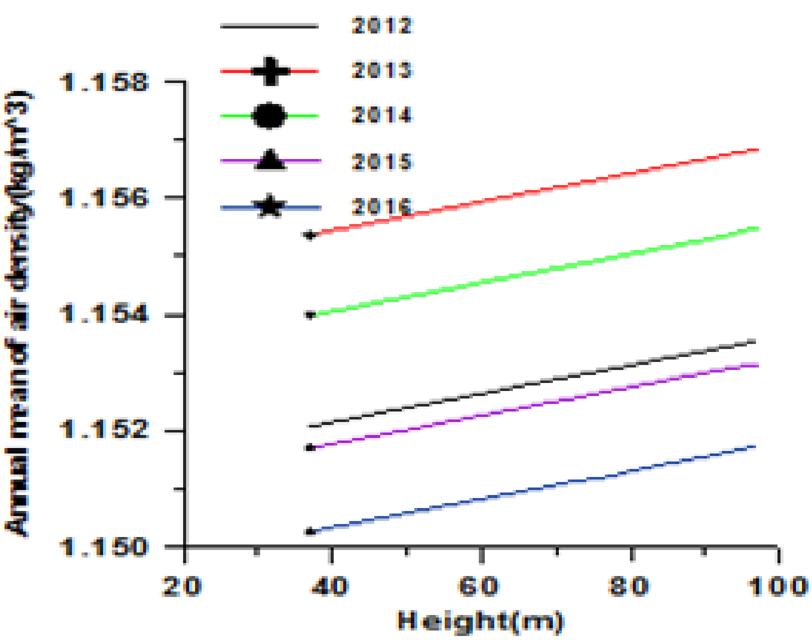


**Figure 6.** Annual mean of air density as a function of height by temperature effect.

with increase in height leads to a decrease in the value of density because of the expansion which takes place in the volume of air mass unite and the free movement of air molecules. The second influence is indicated by the reduction in temperature with the increase in height resulting in the increase of air density because of the decrease of the volume of air mass unit. The study explains that the impact of the second factor dominates the first factor as shown in Figure 9.

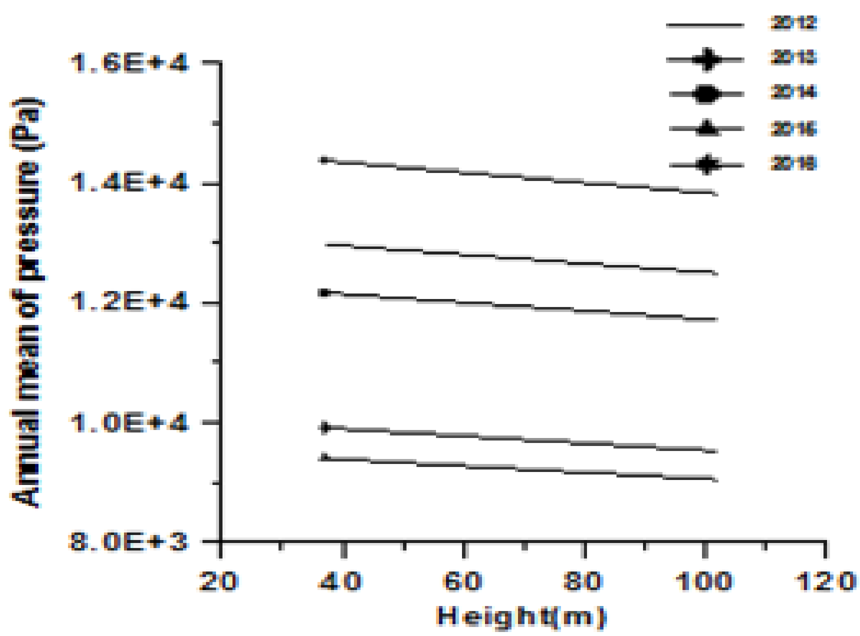


**Figure 7.** The behaviour of annual mean pressure as a function of height.

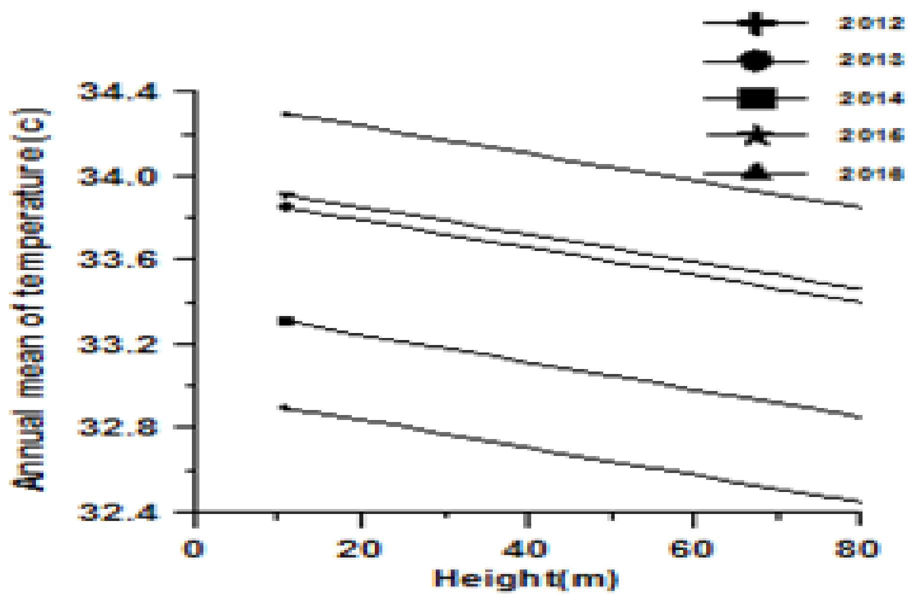


**Figure 8.** The behaviour of temperature annual mean as a function of height.

Figure 9 explains the amount of percentage of loss in wind power annual rates due to temperature influence compared to those rates calculated without taking into account temperature. The fig. also shows the amount of percentage of loss in wind power annual rates as ranging between 4.7% to 5.8%. Figure 10 shows the loss percentage in the annual density of air due to temperature effect compared to those rates calculated without taking

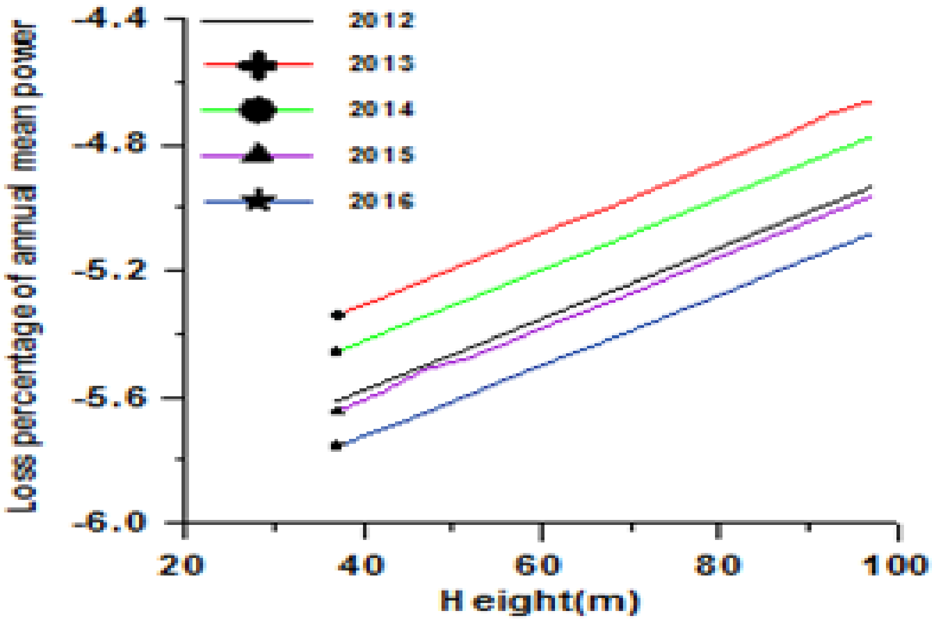


**Figure 9.** The percentage of loss of power annual mean with temperature effect.

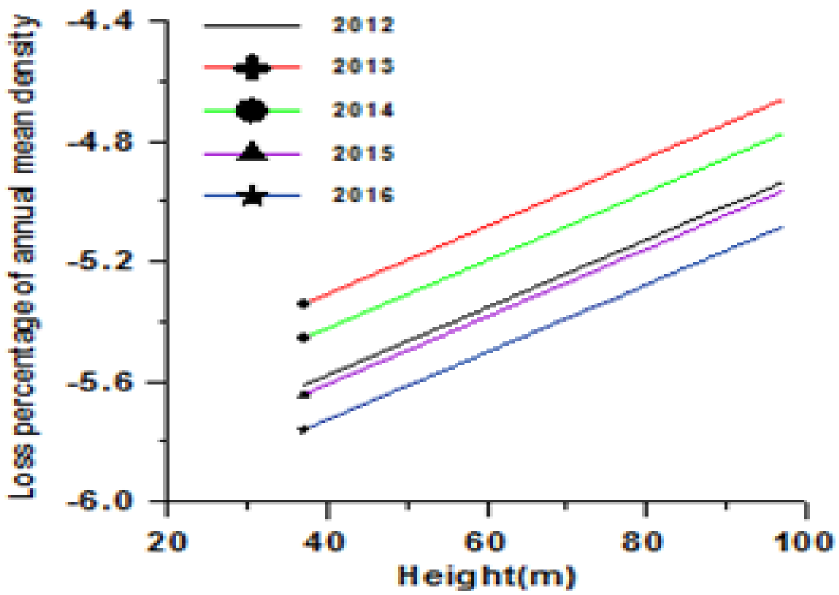


**Figure 10.** The percentage of loss of density annual mean with temperature effect.

temperature effect into account. It is appearing from the Figure that the amount of percentage of loss in annual rates of wind density reduces with the increase in height.

## 4. Conclusion

The study concluded that: 1- The temperature affected the resultant wind power annual rates as a renewable energy in Samawa city south of Iraq. The percentage of loss in wind power annual rates ranges between the minimum value 4.7% at the study period 2013 and the maximum value 5.8% at the study period 2016.The study attributed that to the loss in air density. The percentage of loss in air density annual rates ranges between the minimum values 4.7% at the study period 2013 and the maximum value 5.8% at study period 2016. 2-The amount of percentage of loss in annual rates of wind power reduces with the increase in height.

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