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Evaluation of Wind and Solar For Micro Generation in Urban Coimbatore

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Abstract
This work is to ascertain the hypothesis for setting up a micro generation in an urban area close to Coimbatore, Tamilnadu and South India. Ever increasing urbanisation around Coimbatore offers an exorbitant load to local grid. To meet out the grid load oftentimes-conventional power plants are engaged to their full capacity in turn to which level of toxic emissions into the atmosphere is heightened. Hence quality of air around this area is inferring day by day as well. This air of poor quality may conduce health issues associated to respiratory of populates. Geospatial data of Coimbatore is witnessing the copiousness of renewable energy that can be converted into electrical energy to confront the increasing power requirement of populates. It is well known fact that the production of renewable energy foreshortens toxic outturn of the conventional power plants and nurtures the atmosphere. Annual average wind speed of Coimbatore is 8.06Mph with a mean wind power density of 97kWh/m^2. A good rate of annual diffuse radiation 5.7 kWh/m^2 is registered during this work along with an average day length of 11.9 hrs. 310 number of sunny days in a year is recorded during this study which affirms the hypothesis for solar power generations.

Keywords: *Micro-generation, Renewable energies, Solar photovoltaic, Wind energy*

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I. INTRODUCTION

Electricity consumption per capita is considered as modern index to predict economic growth of a country. Electrical consumption is ever increasing as the number of daily contraptions and households are tremendously increasing since the last decade. Meeting ever increasing electrical demand drives every electrical engineer to find novel and affordable power production concepts. Solar and wind energy are prominent and naturally available resources for the production of renewable energy. Across the globe there are many micro generation stations are employed to support domestic loads. Micro generation could reduce the use of grid power and would be more economical. Comparing to conventional power generation methods micro generation offers about zero toxic contents to atmosphere. This quality of micro generation bolsters its supremacy further.

This paper strives to find out the hypothesis for setting up micro generation in urban area. Most of the population of a country lives by urban side. It is found that urban building has the potential to setup micro generations with renewable energy sources. All the experiments related to this work is carried out at urban area of Coimbatore, Tamilnadu, and South India. Micro generation softens the grid load issues to certain extend. Wind energy is readily available everywhere on the earth at no cost with which energy can be produced. Operation and production cost of wind is very low when compared to the conventional type power production. There are number of reasons for the acceptance of wind power production around the world.

Coimbatore has four types of climate in which more than 300 days out of 365 days sunny days. Coimbatore is situated with a latitude of N 11.000, longitude E 76.875 and an Elevation of 411 m, distance from a nearest seashore is 319 km. Mean temperature 24.3^{o}C. Value of mean pressure is 95.03 kpa with a mean air density 1.104 kg/$m^{3.}$ Yearly Average sunny days for Coimbatore is about 310 days out of 365 days .This huge Number of sunny days provide a greater advantage for setting up solar energy production around Coimbatore. Energy generation with wind and solar produces no CO_2 emission when comparing to conventional methods. Mitigation of CO_2 is most concerning thing amidst of the scientist around the globe as global warming is a

menace to the entire living creatures on this beautiful earth. So it is very right time for researchers to find an alternate for the conventional power generation. In addition to this power production at low cost will also promote the economic power of the nation. Micro generation is an apt technology for reducing diffusion of CO_2 in atmosphere and to abbreviate grid load.

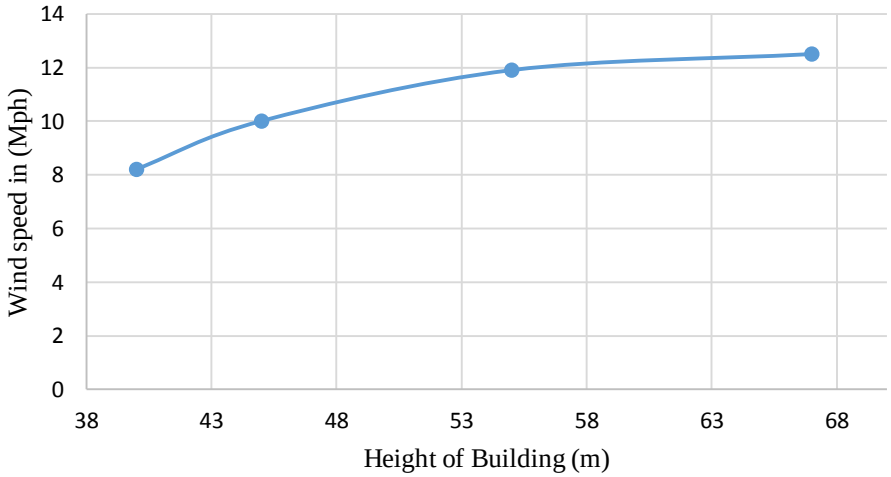
II. WIND POTENTIAL ASSESMENT

The hard part of this work was establishment of experimental setup over all the tall and small buildings. Therefore to calculate the wind speed on buildings with varying height a HTC anemometer VB-8205 (HTC137ANHT140417) was attached to pole of 5 meters height from the ground level which is considered as an average residential building. Using logarithmic law this height is then extrapolated to the building height which is to be measured, with an assumption that the rate of movement of wind is proportional to the logarithm of the height from the ground level. Formulae used for this calculation is given below,

$$C = C_{ref} \left\{ \frac{\ln\left(\frac{h}{h_o}\right)}{\ln\left(\frac{h_{ref}}{h_o}\right)} \right\}$$

Where, href is Reference height (m), 'h' is height where wind speed (m) is to be determined, h0 is Measure of surface roughness (0.11 to 0.251 for crop land), C is Wind speed at building height (m/s), and Cref Wind speed at the reference height (m/s).

Figure 1: Extrapolation of wind speed



Further to extrapolation, change in wind speed with respect to height of building were calculated at various locations which has low ground roughness by applying the following equation,

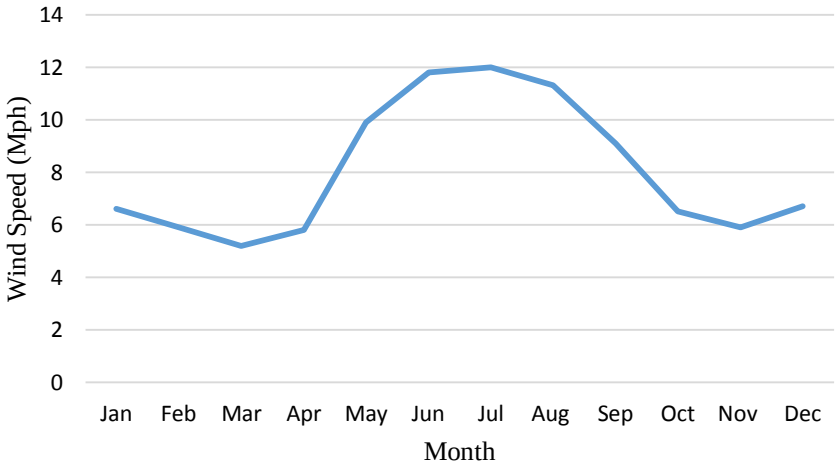
$$\frac{C_2}{C_1} = \left(\frac{h_2}{h_1}\right)^{\propto}$$

Where C1 and C2 are wind speeds at levels h1 and h2 $\propto$ is the power law index. This power law index is derived with the help of following formula.

$$\propto = \frac{logC_2 - logC_1}{logh_2 - logh_1}$$

By adopting the foresaid method and equations wind speed data were collected and calculated from and for several urban area belongs to Coimbatore. With the help of these data annual average wind speed of Coimbatore urban area was calculated and plotted as a graph shown below

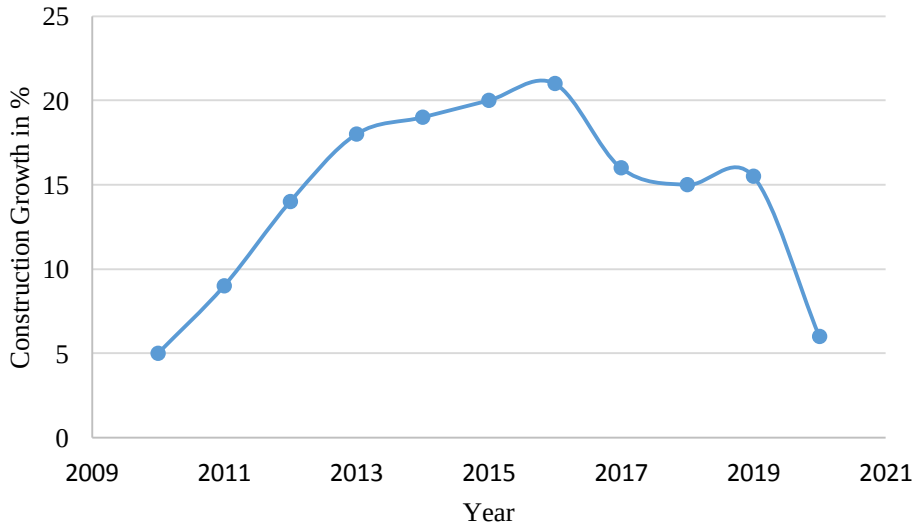
Figure 2: Wind speed



From the collected data annual average wind speed rate of Coimbatore is found to be about 8.06 Mph which is more than sufficient for setting up a micro generation. Also this study revealed that Maximum Wind power density of Coimbatore 230W/m2, Mean wind power density 97W/m2 and mean energy content 840 kWh/m2/year.

In technical perception this work revealed a positive hypothesis for setting up wind energy on the roofs of these urban area. On other hand rate of urbanization here in these focused area are recorded as 15% increase by annual. This culture of rapid urbanization happening here encourages the number of building to grow more and more which directly barricades the free flow of air. Hence it is hard to predict the period for ROI (Return of Investment). Without a firm idea about ROI period setting up wind generation would not be that much beneficial in view of economics. A graph related to the growth of building constructions has been plotted with the data collected from many locations from Coimbatore is shown below,

Figure 3: Growth of Building Construction



III. SOLAR POTENTIAL ASSESSMENT

The principal parameter used here for solar potential assessment is the mean of monthly solar radiation. According to the data collected out of 365 days in Coimbatore about 310 days are found to be sunny days. Which is most convinced factor for setting up a solar power production. Following equation is adopted in the calculation of monthly average solar radiation.

$$\boldsymbol{\phi}\text{ave} = \boldsymbol{\varphi}\text{ave}\left\{\text{a} + \text{b}\left(\frac{\alpha_{ave}}{\beta_{ave}}\right)\right\}$$

here $\boldsymbol{\phi}$ave is horizontal surface's monthly average daily radiation (MJ/m2), $\boldsymbol{\varphi}$ave is horizontal surface's monthly average daily extra-terrestrial radiation (MJ/m2), βave is the utmost possible daily hours of bright sunshine, αave is monthly mean day by day number of hours of bright sunshine, a and b are Coefficients of regression having average value of a =0.329 and b=0.429. Besides an empirical equation is also used for estimating the Availability of solar radiation in Coimbatore locations is as follows,

$$\frac{R_m}{R_{csky}} = x + y\left(\frac{d_L}{d_{max}}\right)$$

Where Rm monthly average of daily global radiation on a horizontal surface at a given location, MJ/m2/day. Rcsky monthly average of daily global radiation on a horizontal surface at the same location on a clear sky day, in ((MJ/m2)/ (day)). dL monthly average measured solar day length in hours. dmax monthly average of longest day length in hours .x,y constants for location with the values of 0.309 and 0.469erspectively.During this course of work prediction of the clear sky day was a great challenge hence it is decided to replace Rm with Rmo. This Rmo is extra-terrestrial radiation's monthly average for the focused location. Therefore our earlier equation is modified as

$$\frac{R_{mo}}{R_{csky}} = x + y\left(\frac{d_L}{d_{max}}\right)$$

Rmo can be calculated using the equation

$$\mathrm{R_{mo}} = \frac{24}{\pi}\, I_{sc}\left(1 + 0.033\cos\frac{360n}{365}\right)(\omega_s\, sin\Phi \sin\delta + cos\Phi\cos\delta sin\omega_s)$$

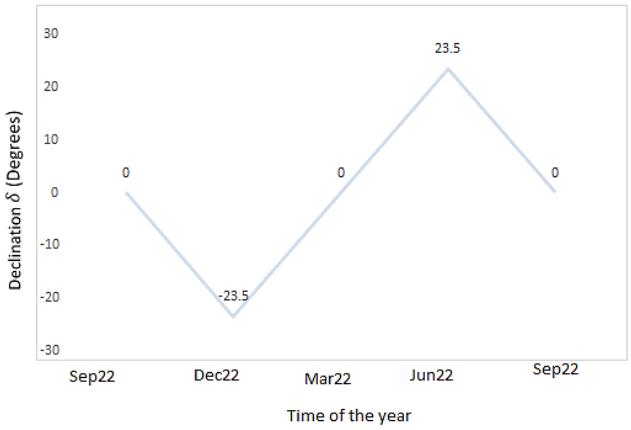
Where Isc Solar constant per hour, ω_s Sunset hour angle, δ declination angle and n is day of the year.

Sunset hour angle $\omega_s = 2cos^{-1}(-tan\Phi\tan\delta)$

Declination angle $\delta = 23.5\sin\left\{\frac{360}{365}(284+n)\right\}$

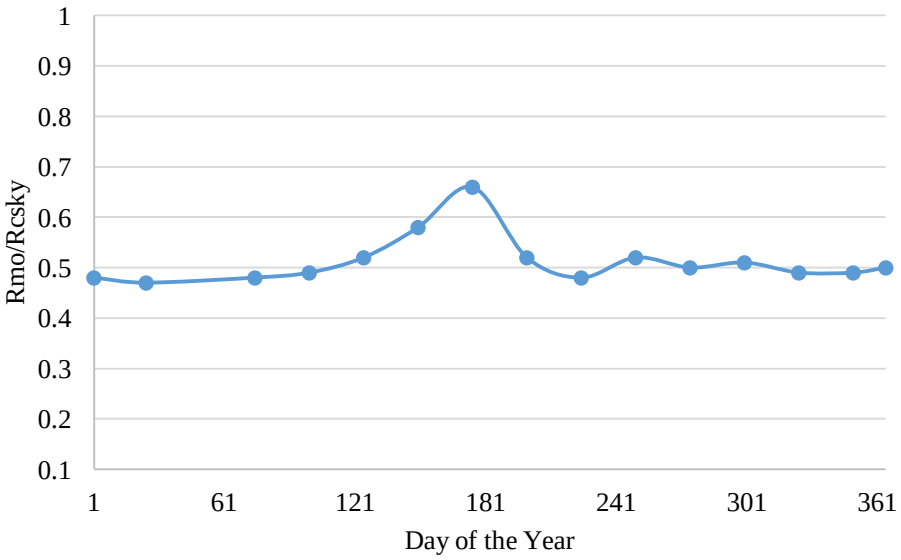
It is observed from this study that sun declination angle ranges from -24^o ≤ δ ≤ +24^o. During the autumnal and vernal equinox days sun declination angle measure is considered as 0^o. The reason is at this two incidents centre of the earth lies in the plane of sun so there will be 12 hours of sunshine on any location of the earth.

Figure 4: Twelve hour Sunshine



Clearness index of Coimbatore is in a range of $0.3 < K_T < 0.7$. Measured range of clearness index in Coimbatore fits with the required amount of clear sky days. Therefore it is recommended to setup roof top solar photovoltaic panels on the focused area urban buildings. Supporting clearness index values of focused Coimbatore urban area are plotted as graph below

Figure 5: Clearness Index

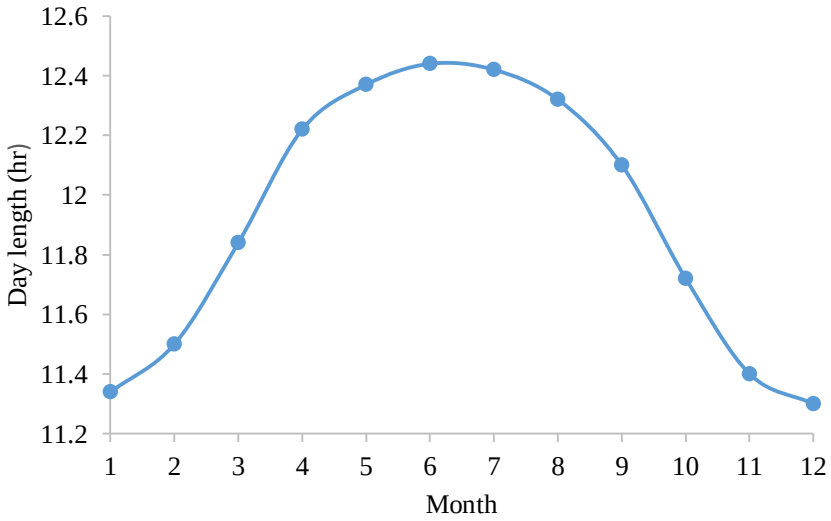


Day length plays a vital role in selection of location for setting up solar PV. Therefore, data regarding the day length of Coimbatore is also collected. Calculation of day length was executed by using the below formula.

$$L_D = \frac{2}{15} cos^{-1}(-tan\Phi tan\delta)$$

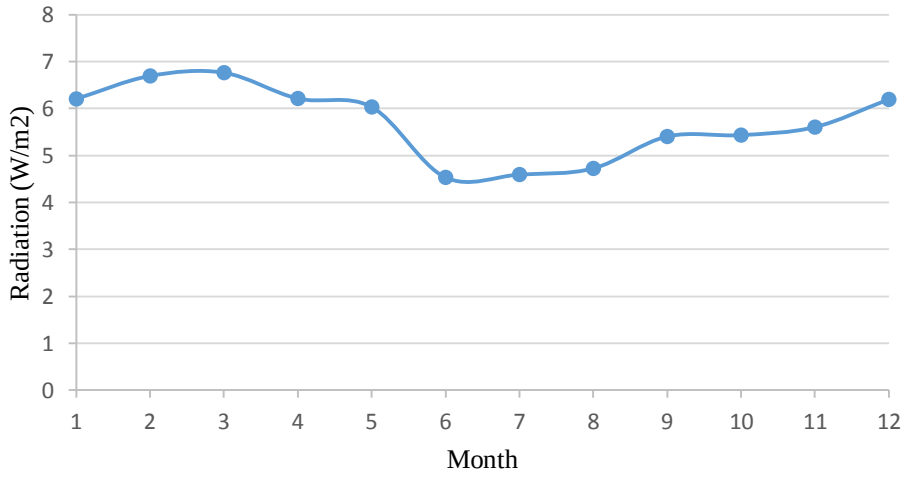
Estimated value of average day length of Coimbatore after calculation is found to be 11.9 hours, which is befit to set up solar energy system.

Figure 6: Day length



Coimbatore lies with a latitude of N11.000.Monthly average diffuse radiation for Coimbatore has shown good results for setting up micro generation with a diffuse radiation of 5.7 kWh/m2, following graph briefs it.

Figure 7: Average monthly diffuse radiation



Coimbatore has good potential for solar power generation since it has 310 sunny days out of 365 days in an average. Coimbatore has vast building areas since it has so many infirmaries and education institutions. Considering the residential area in an average Coimbatore has more number of buildings which has minimum of 1500 ft2 which provides ample surface for solar energy.

IV. CONCLUSION

Hypothesis for Micro generation was done successfully with various and useful data. Undoubtedly micro generation will cut down the grid load to a significant level. Wind flow of Coimbatore is plenty when comparing to the wind energy production's minimum requirement. Wind energy production, solar PV outstands the requirement as well. Landscape of Coimbatore urban area are well supporting to the micro generation. While considering the ROI (Return of Investment) period of both wind energy and solar PV it takes up to 5-7 years of duration, depending on the size and capacity of the installation it may vary to 10+ years as well. On other hand in and around Coimbatore urbanisation is geared up about 15 percentage in an average since last decade. Therefore choosing a right place to setup micro generation in urban area requires more and careful considerations. Buildings which has vast roof space are advisable to setup micro generation in urban area. Technically Coimbatore has a potential for setting up micro generation since topographical factors are very fair when comparing to other urban places in Tamilnadu, South India. Only the increasing rate of buildings that build for urbanisation is what chokes up possibilities for micro generation. Hence further studies related to urban planning are suggested to utilise the abundant renewable resources in Coimbatore.