IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 04, Issue 12 (December. 2014), ||V4|| PP 58-63

Semi Hourly Wind Speed Pattern and Battery Backup Sizing for Micro-Scale Hybrid Solar and Wind Systems in Armidale NSW, Australia

Yasser Maklad[1]
[1]*(University of New England, Armidale NSW 2351 NSW Australia– School of Environmental & Rural Science - email: ymaklad@myune.edu.au)*

Abstract:-Wind and solar energy sources has intermittent nature, there behaviour of fluctuant speed and direction for wind and solar irradiance and sunshine hours for solar vary for the same region from season to season or month to month, rather from a second to the following second. Such intermittency and unpredictability presents a rationale behind the need of battery backups for micro-scale hybrid solar and wind systems, in order to cope with such variance against the electrical load demand needs to be fulfilled.
This article utilised semi hourly wind speed observations recorded at Armidale city in New South Wales in Australia, those observations covered the period of (1993-1913) and was measured at Armidale Airport Automatic Weather Station. Utilising the Test Reference Year (TRY) calculation methodology, a data base of semi hourly wind speed values for a typical day for a typical year has been developed. Average semi hourly wind speed observations on annual basis along with TRY daily solar irradiance developed in another earlier article are studied together approaching typical houses load in Armidale in all seasons are discussed. Thus conclusions provided recommendations for battery backup sizing for micro-Scale hybrid solar and wind systems.

Keywords: *- Armidale NSW, test meteorological year, test reference year, wind speed, micro-scale energy generation, micro-wind turbines, battery backup sizing.*

I. INTRODUCTION

The most common data for describing the local wind climate is through what is called Typical Meteorological Year data (TMY). To determine TMY data, various meteorological measurements are made at hourly intervals over a number of years to build up a picture of the local climate. A simple average of the yearly data underestimates the amount of variability, so the month that is most representative of the location is selected. For each month, the average wind speed over the whole measurement period is determined, together with the average wind speed in each month during the measurement period. The data for the month that has the average wind speed most closely equal to the monthly average over the whole measurement period is then chosen as the TMY data for that month. This process is then repeated for each month in the year. The months are added together to give a full year of hourly samples. There is no strict standard for TMY data so the user must adjust the data to suit the application. Considerable care must be taken with sample periods. Wind speed data is a crucial parameter for the prediction of long-term performance of wind energy generation systems. As well, it is a key input in modelling and designing of wind energy applications. Thus, a need for a reliable source of wind speed data has to be readily available for particular settlement locations.

The need for a one-year representative daily meteorological data led to the development of methodologies known as the Typical Meteorological Year (TMY), alternatively called Test Reference Year (TRY) [1]. TMY or TRY is a representative data that consists of the month selected from the individual years and concatenated to form a complete year. However, A TMY is not necessarily a good indicator of conditions over the next year or even the next five years. Rather, TMY represents conditions judged to be typical over a long period of time [2]. Typical weather year data sets can be generated for several climatic variables such as temperature, humidity, wind speed, etc. or only for wind speed. Various trials have been made to generate such weather databases for different areas around the world [1, 3, 4, 5, 6, 7, 8, 9, 10, 13 & 14].

Photovoltaic solar energy and wind energy conversion systems have been widely used for electricity supply in remote and isolated locations far from the electricity public distribution network. These systems provide a relatively reliable source of electricity generation and operate in an unattended manner for extended periods of time if they are properly sized, designed and maintained. However, these systems does suffer from the natural fluctuating attributes solar and wind energy sources, this fluctuation have to be addressed and solved during the initial stages of the PV system design [16 & 17].

Thus, the optimal sizing of a stand-alone PV system with a battery storage is a far important aspect of system efficient functionality. Several factors, such as climatic data, system's component costs, and the temporal distribution of the electric load have to be taken into consideration in the PV system design, as well [18].

The main objective of the present study is to determine the effect of utilising short term (semi hourly) wind speed values on the sizing of micro scale hybrid solar and energy system and their supported battery backup systems to fulfil the hourly electrical demand of typical households in Armidale NSW, Australia.

II. DATA AND LOCATION

A previously meteorological wind speed TRY at 10m height was developed [11]. That TRY was generated based on the daily mean wind speed recorded during the period 1994–2010 recorded at Armidale's Airport Weather Station (AWS). That TYR was generated utilising Finkelstein-Schafer (FS) statistics [12].
In Australia, meteorological observations are recorded by the Australian Bureau of Meteorology (BOM) weather stations are widely spreader in lots of cities and towns around Australia. In this study, the global wind speed data recorded by Armidale Airport Weather Automatic Station and published on the BOM's website where it was collected. The missing and invalid measurements account for 0.001% of the whole database of mean wind speed; those were replaced with the values of preceding or subsequent days by interpolation. During the calculations process, any year found with more than ten days in any month observations not available was excluded. "Table 1" provides geographical information for Armidale town and the periods of the relevant mean wind speed data and "figure 1" shows Armidale's location in NSW, Australia.

Table 1 Geographical and mean wind speed database information of Armidale NSW, Australia

	Longitude (†E)	Latitude(†S)	Elevation (m)	Mean Daily Wind Speed	
				Period	Total years
Armidale	151.67	30.52	970-1070	1993—2013	21

Figure 1 Armidale NSW, Australia location

III. METHODOLOGY

Finkelstein-Schafer (FS) statistics [11] is a nonparametric statistical method, known as common methodology for generating typical weather data [1, 2, 3, 4, 5, 8, 9, 10 &12]. In this study, FS methodology is used for generating the typical wind speed year. According to FS statistics [11], if a number, n, of observations of a variable X are available and have been sorted into an increasing order X1, X2,. . ., Xn, the cumulative frequency distribution function (CDF) of this variable is given by a function Sn(X), which is defined in equation (1).

IV. $$S_n(X) = \begin{cases} 0 & For\ X < X_1 \\ \frac{(K-0.5)}{n} & For\ X_k < X < X_{K+1} \\ 1 & For\ X > X_n \end{cases} \quad (1)$$

where k is rank order number. The FS by which comparison between the long-term CDF of each month and the CDF for each individual year of the month was done is given in equation (2).

V. $$FS = \left(1/_N\right) \sum_{i=1}^{n} \delta_i \quad (2)$$

VI.

where i is the absolute difference between the long-term CDF of the month and one-year CDF for the same month at Xi (i = 1, 2, n), n being the number of daily readings of the month. di and F(Xi) are expressed with the following equations (3 &4).

$$\delta_i = max\left[\left|F(X_I) - \frac{(i-1)}{n}\right|, \left|F(X_i) \ - \frac{i}{n}\right|\right] \quad (3)$$

$$F(X_{i)} = 1 - \exp\left(-X_i/_{\bar{X}}\right) \quad (4)$$

where Xi is an order sample value in a set of n observations sorted in an increasing order and X is the sample average.

Finally, the representative year for each month of the data set was determined on the basis that the representative year is that of the smallest value of FS as in equation (5).

$$TRY = MIN(FS) = MIN(\delta_i) \quad (5)$$

VII. GENERATION OF TYPICAL SEMI HOURLY WIND SPEED REFERENCE YEAR

Applying the above methodology for the collected semi hourly wind speed measured at Armidale Airport Automatic Weather Station during the period (1993-2013), a data base of semi hourly wind speed for each day of a TRY is generated.

Table 2 shows the average meteorological TRY for semi hourly wind speed measured at 10 meter height in (m/s) at Armidale Airport Automatic Weather Station.

Table 2 Meteorological average annual semi hourly wind speed values in Armidale based on TRY

Time over 24 Hours	**0:00**	**0:30**	**1:00**	**1:30**	**2:00**	**2:30**	**3:00**	**3:30**
Average Wind Speed in m/sec	5.63	5.78	5.19	4.73	4.82	4.79	5.00	4.93
Time over 24 Hours	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30
Average Wind Speed in m/sec	5.61	5.77	5.18	4.72	4.81	4.77	4.99	4.91
Time over 24 Hours	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30
Average Wind Speed in m/sec	5.60	5.75	5.16	4.70	4.79	4.76	4.97	4.90
Time over 24 Hours	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30
Average Wind Speed in m/sec	5.58	5.73	5.14	4.69	4.78	4.74	4.96	4.88
Time over 24 Hours	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30
Average Wind Speed in m/sec	5.56	5.72	5.13	4.68	4.76	4.73	4.94	4.87
Time over 24 Hours	20:00	20:30	21:00	21:30	22:00	22:30	23:00	23:30
Average Wind Speed in m/sec	5.55	5.70	5.11	4.66	4.75	4.72	4.93	4.86

Plotting data in table 2, resulted in figures 2 & 3, it is clearly shown that average semi wind speed are highly concentrated on the period between 9:00am and 7:00am.

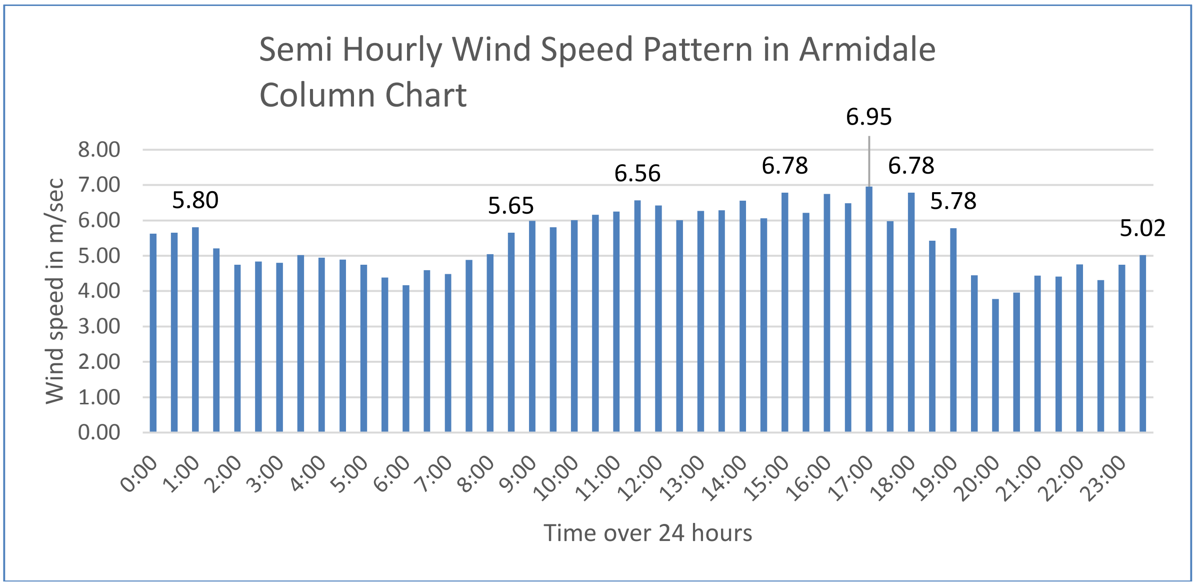

Figure 2 Average annual semi hourly wind speed pattern in Armidale – Column Chart

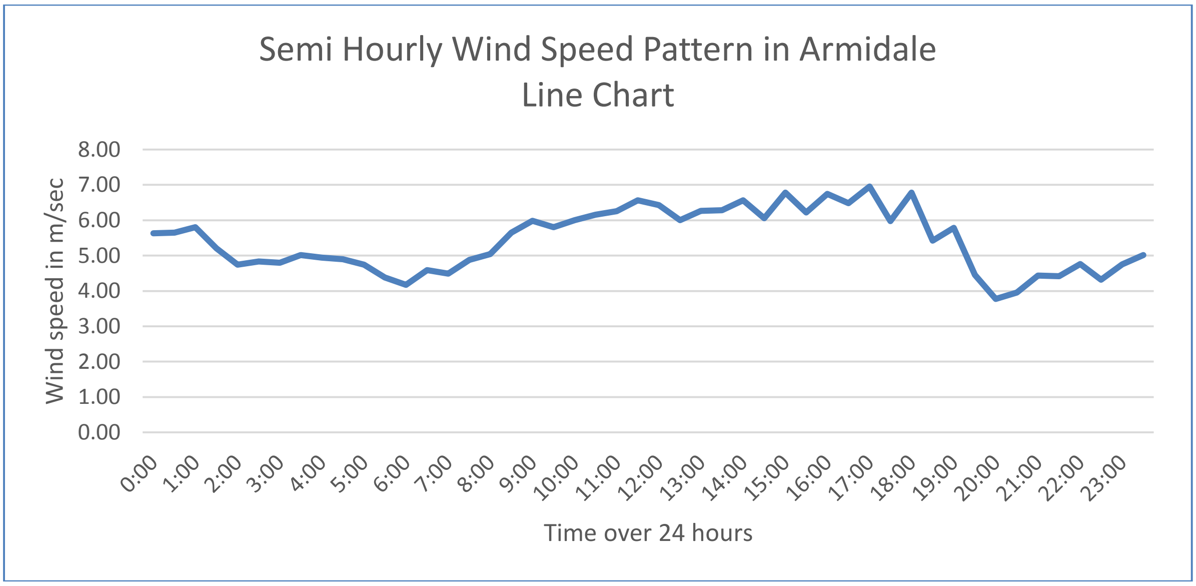

Figure 3 Average annual semi hourly wind speed pattern in Armidale – Line Chart

Table 3 shows typical electric load consumption for several occupancies in Armidale and seasons, figure 4 shows that the maximum electrical load for domestic buildings in Armidale is the highest between (07:00-08:00) am which is the time households prepare themselves to go for work, schools, etc… and between (17:00-18:00) pm which is the time households mostly come back home and start cooking and other activities.

Approaching micro-scale hybrid wind and solar systems supported with battery backups, taking into consideration that effective sunshine hours is usually during (07:00 am – 17:00 pm), and considering the average semi hourly wind speed generate din this study. It is significantly important for battery backup systems' designers to consider that there intended battery backup system will be charged by solar and wind energy in the period (08:00 am – 17:00 pm) to be consumed significantly by households in the period (17:00 pm – 18:00 pm).

On the other hand, the other peak electrical load at (07:00 am -08:00 am) will not have enough power in there battery backup system, no solar energy yet.
This would significantly lead to the a fact that battery backups should be almost double sized, as well the capacity of the hybrid solar and wind micro scale systems to cope with the daily electrical demand.

Table 3 Average electric load consumption seasonally for households in Armidale

Season	Months	1 Occupant		2 Occupants		4 Occupants		6 Occupants	
		Total kWh	Avg. Daily kWh	Total kWh	Avg. Daily kWh	Total kWh	Avg. Daily kWh	Total kWh	Avg. Daily kWh
Winter	Jun–Jul-Aug	1700	18	2255	23	3160	32	4070	42
Spring	Sept-Oct-Nov	1150	13	1440	16	2020	22	2600	29
Summer	Dec-Jan-Feb	1300	15	1630	18	2280	25	2940	33
Autumn	Mar-Apr-May	1100	12	1380	15	1930	21	2490	27

Extracted from [19]

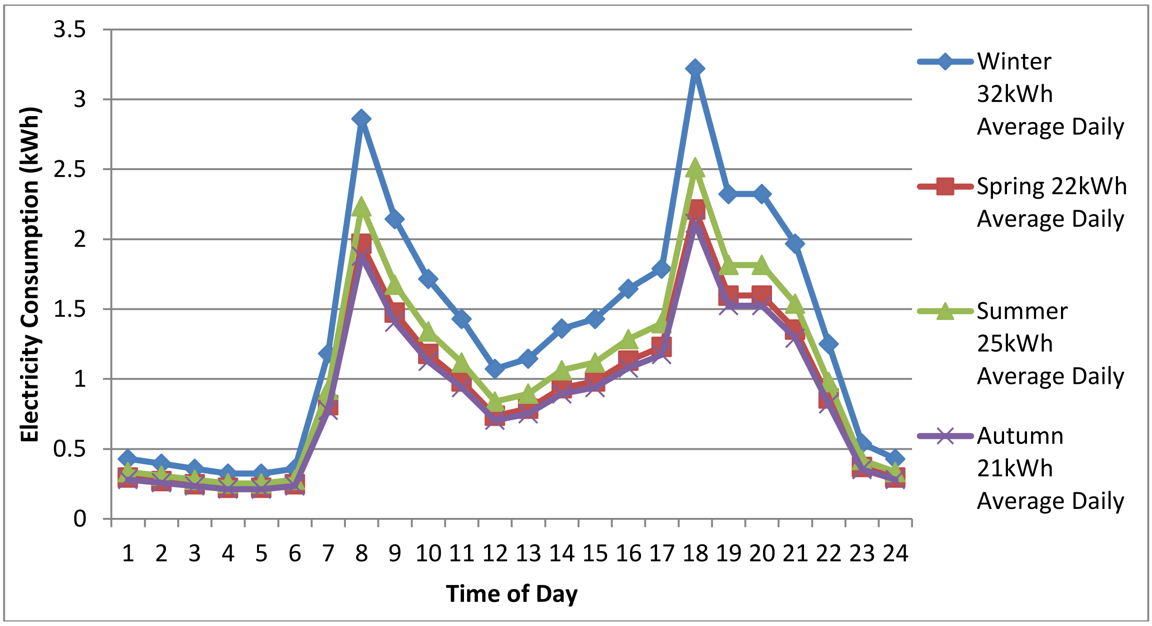

Figure 4 Typical daily hourly electrical consumption load pattern for the four seasons in Armidale
Extracted from [20]

VIII. CONCLUSION AND RECOMMENDATIONS

Many households utilising micro scale hybrid solar and energy systems supported with battery backup systems are frustrated with the lack of performance of their energy systems. Such frustration would rises from under sizing of the capacity of the solar and wind generators itself and/or the under sizing of the battery backup capacity, such under sizing occurs often due to the fact the many energy system designers base their energy calculations on long term historical recorded solar and data measured. Such long term data would present the trend of the solar and wind but not necessarily reflects the actual happening at real.

This study based on short term “semi hourly) wind speed values recorded in Armidale, provided an analysis of micro scale hybrid solar and wind systems with backup systems versus hourly electrical load consumption for typical houses’ occupancies in Armidale.

The study rings an alarm that based on short term data, there might be a need to double size the system capacity and/or the battery backup systems to cope with the designed load to avoid future frustrations and complaints from households, by all means this would represent a huge impact on the energy systems costs which will affect the households decision making process regarding utilising micro-scale hybrid solar and wind systems.

REFERENCES

[1] A. Argiriou, S. Lykoudis, S. Kontoyiannidis, C.A. Balaras, D. Asimakopoulos, M. Petrakis, and

P.Kassomenos. Comparison of methodologies for TMY generation using 20 years data for Athens, Greece. *Solar Energy* 66(1), 1999, 33–45.

[2] W. Marion and K. Urban. User's Manual for TMY2s. National Renewable Energy Laboratory, Colorado, USA, 1995.

[3] H. Bulut. Generation of typical solar radiation data for Istanbul, Turkey. *International Journal of Energy Research* 27(9), 2003, 847–855.

[4] H. Bulut. Typical Solar Radiation Year for South-eastern Anatolia. *Renewable Energy* 29(9), 2004, 1477–1488.

[5] R.L. Fagbenle. Generation of a test reference year for Ibadan, Nigeria. *Energy Conversion and Management* 30(1), 1995, 61–63.

[6] J.C. Lam, S.C.M. Hui, and A.L.S. Chan. A statistical approach to the development of a typical meteorological year for Hong Kong. *Architectural Science Review* 39(4), 1996, 201–209.

[7] A. Miguel, and J. Bilbao. Test reference year generation from meteorological and simulated solar radiation data. *Solar Energy* 78(6), 2005, 695–703.

[8] M. Petrakis, H.D. Kambezidis, S. Lykoudis, A.D. Adamopoulos, P. Kassomenos, I.M. Michaelides, S.A. Kalogirou, G. Roditis, I. Chrysis, and A. Hadjigianni. Generation of a typical meteorological year for Nicosia, Cyprus. Renewable Energy 13(3), 1998, 381–388.

[9] S.A.M. Said and H.M. Kadry. Generation of representative weather-year data for Saudi Arabia. *Applied Energy* 48(2), 1994, 131–136.

[10] M.A.M. Shaltout and M.T.Y. Tadros. Typical solar radiation year for Egypt. *Renewable Energy* 4(4), 1994, 387–393.

[11] J.M. Finkelstein and R.E. Schafer. Improved goodness of fit tests. *Biometrika* 58(3), 1971, 641–645.

[12] G. Kalogirou, I. Roditis, II. Chrysis, and A. Hadjigianni. Generation of a typical meteorological year for Nicosia, Cyprus. *Renewable Energy*: 13(3), 1998, 381–388.

[13] L. Q. Liu and Z. X. Wang. The development and application practice of wind-solar energy hybrid generation systems in China. Renewable and Sustainable Energy Review 13(6-7), 2009, 1504–1512.

[14] T.N Anderson, M. Duke and J.K. Carson. Generation of a typical meteorological year for Harcourt zone. Journal of Engineering Science and Technology 6(2), 2011, 204-2014

[15] Y. Maklad. Generation of an Annual Typical Meteorological Solar Radiation for Armidale NSW, Australia. *IOSR Journal of Engineering (IOSRJEN)* 4(4), 2014, 41-45.

[16] AD. Sahin, Z. Sen. (1995). Refined wind energy formulation and its application in Turkey. The Second International Conference on New Energy Systems and Conversions, July 31–August 3, pp. 357–360.

[17] T. Markvart. (1996), Sizing of hybrid photovoltaic-wind energy systems. Solar Energy, 57 (4):227–281. Mayhoub, AB., Azzam, A. (1997), A survey on the assessment of wind energy potential in Egypt. Renewable Energy, 11(2):235–247.

[18] A. Hadi Arab, B.A., Driss, R. Amimeurand E. Lorenzo. (1995), Photovoltaic systems sizing for Algeria. Solar Energy, 54 (2):99–104.

[19] Y. Maklad. (2014). A Hybrid Renewable Energy System (Wind and Solar) size optimization and costing for residential buildings in Urban Armidale NSW, Australia. Economics and policy of energy and environment, 1.

[20] Y. Maklad. (2014).Quantification and Costing of Domestic Electricity Generation for Armidale, New South Wales, Australia Utilising Micro Wind Turbines. International Journal of Energy Economics and Policy, 4 (2): 208-219.