HYBRID WIND-SOLAR AND BATTERY STORAGE SYSTEM:CASE STUDY IN UIT RGPV BHOPAL

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Abstract **-** This study was developed to understand the nature of power storage capacity and characteristics of a hybrid wind-solar generation unit. Using Catia, Ansys and excel tools the results obtained were used to solve the impact of such dynamic phenomena on the operation, stability and power storage capacity of the overall system. Finally, remedial measures were developed to establish the Load-Power profile. This research was done on a hybrid wind-solar and battery system installed in a university campus UIT Bhopal. The system has one wind turbines 1.3kW and a PV system .3 kW connected to a 12V battery system through charge controllers.

Index Terms - Solar energy, Wind energy, Renewable energy, PV cell, Battery Storage improvement**.**

I. INTRODUCTION:

This study was developed to understand the nature of power storage capacity and characteristics of a hybrid wind-solar generation unit. Using Catia, Ansys and excel tools the results obtained were used to solve the impact of such dynamic phenomena on the operation, stability and power storage capacity of the overall system. Finally, remedial measures were developed to establish the Load-Power profile. This research was done on a hybrid wind-solar and battery system installed in a university campus UIT Bhopal. The system has one wind turbines 1.3kW and a PV system .3 kW connected to a 12V battery system through charge controllers. The renewable energy technology today is maybe the main tool our society has to replace the fossil-fuel-based energy systems. Wind and solar energies, in particular, are green and free sources, available nearly everywhere and every day, especially, if we combine them in a hybrid apparatus capable of merging their statistical availability. What is not properly everywhere is the electrical energynetwork. The resulting lack of public illumination can often represent a significant obstacle to the progress of those areas. With this regard, distributed renewable energy can play an important role in providing electricity close to its consumption. In particular, it has been proposed to integrate wind and solar energy directly into a power storage device using LI-ion battery, making the storage capacity more independent of the present storage capacity, or even fully standalone where the minimal climate conditions are met

This work addresses the matter through the implementation of a test site to study hybrid micro-wind and solar systems and the analysis of a storage capacity, study is based to installed prototype, already commissioned and developed by an academic-industrial partnership within a project sponsored by the UIT Bhopal.

LITERATURE REVIEW:

The different researches were carried out on the solar and wind power generation. The utilization of renewable energy required system. The literature carried out with categorization of the different system stand alone as follows:

1. Stand Alone Solar System:

Abhaya Swarup et al developed a model for energy management of PV based energy system. This model has been mainly proposed to raise the public awareness and education levels of solar systems in an interesting and entertaining way. The results indicate that the problems with PV systems were not due to PV array and instead it was due to the performance of the battery units.
Martina et al have discussed about multilevel converters that are effectively used to connect single phase grid with solar photovoltaic systems. An overview of different multi level topologies and the suitability for single-phase grid connected photovoltaic systems has also been presented.

Vivek Kapil et al have developed an Artificial Neural Network (ANN) model for designing PV systems for remote areas and presented the influence of various parameters on the design of PV systems. The results of ANN model showed a variation of 5% as compared to other models with more reliability and accuracy. The application of solar power is varied and the scope of PV systems being employed even in domestic applications appears to be bright.

Bhattacharaya et al developed a simplified design approach and economic appraisal of a solar PV system. In this model, the PV array and battery bank sizes for a standalone PV system were estimated. Also a cost comparison of the standalone PV system with a PV diesel hybrid system was presented. The resultsindicate that the hybrid systems were cost effective than standalone systems for a given location.

Kshitij Kaushik et al developed a knowledge based model for the design of standalone solar photovoltaic system. This approach combined both the site and array characteristics as a single parameter, referred to as an equivalent unit array output.

Hamid Marafia studied the feasibility of photovoltaic technology for power generation and presented comparative economic analysis of power generation with a conventional gas turbine. The results indicate that the solar photovoltaic systems are not economical as compared with a conventional gas turbine. However, it was concluded that

PV systems could become economical when the system cost reduces to below $2.50 per peak Watt with conversion efficiency above 20%.

2. Standalone Wind Systems:

Aydogan Ozdamar et al have analyzed and presented a case study on wind energy utilization in a house in Izmir, Turkey. The developed model determines the number of batteries needed for continuous energy supply, for each wind turbine taking into account of the economical aspects. It was found that the wind battery hybrid system was not economical in the areas of low wind potential.

Kanat A. Baigarin et al have discussed about the potential of wind energy resources available in central Asia. The equations used for determining the distribution of wind energy output, energy density, energy cost and efficiency have been discussed in detail.

Suresh H. et al have developed a model to investigate the optimum sitting of wind turbine generators based on site and wind turbine type. The methodology of analysis was based on the accurate assessment of wind power potential of various sites. The analytical computation of annual and monthly capacity factors has been carried out by using the weibull statistical model employing cubic mean cube root of wind speeds. A judicious choice of potential sites and wind turbine generator systems can be made using the model proposed.

wen-jei Yang adopted the same principle for determining the power generation by a wind machine and discussed about the utilization of excess wind power for hydrogen storage and subsequent secondary power generation. Rogers et al (2002) studied experimentally the design requirements for a medium sized wind turbinefor remote and hybrid power systems. Also, the operational problems of installing medium and large sized wind turbines at remote locations have been addresse

3. Solar Photovoltaic Wind Hybrid System

Bhave A.G studied the techno-economic feasibility of installing solar photovoltaic-wind hybrid system. This system uses electrical storage by lead acid battery and auxiliary power from AC mains. The result from the above study showed that 80% of the energy demand was satisfied by the solar photovoltaic wind hybrid system. But it was cost effective, only when the system cost was considerably reduced or the current electricity cost raised to a much higher level.

Francois Giraud et al analyzed a model for design of wind–photovoltaic system with battery storage for grid connected rooftop system. The system was designed to meet a typical load demand for a given loss of power supply probability. The various parameters like system reliability, power quality, loss of supply and effects of the randomness of the wind and the solar radiation on systems design have been studied. The results showed that the wind and solar systems were complementary to each other and resulted inmproved reliability of the system.

Rajesh Karki developed a simulation method for photovoltaic and wind energy utilization in small isolated power systems based on reliability/cost implications. This simulation method provides objective indicators to help system planners decide upon appropriate installation sites, operating polices selection of energy types, sizes and mixes in capability expansion. In this model, cost and reliability are the main parameters to be considered as it has a significant impact on the design.

Celik A.N. developed a novel optimization technique for techno-economic analysis for autonomous small scale photovoltaic wind hybrid energy system. An optimum combination of the hybrid photovoltaic wind energy system could provide higher system performance than either of the single system. It was shown that the magnitude of the battery storage capacity has important influence on the system performance of a single PV and wind system.

METHODOLOGY:

A meteorological mast has been installed on the hill nearby the prototype, in order to measure the climate variables over long periods and characterize the site from Wind energy, solar radiation and other climate point of view. The mast has been equipped with the following instrumentation. Using a

- Cup anemometer for the wind speed.
- Wind goniometer for the wind direction.
- Barometer for the atmospheric pressure.
- Air temperature and humidity sensor.
- Solar radiometer for the global radiation.
- Solar radiometer for the direct radiation.
- Data logger with GPRS communication system : variables averaged over 10 min periods.

Meteorological tower allowed to perform a statistical analysis of the available wind energy in this site. With the latter direction, the wind turbines happen to be aerodynamically shadowed by the buildings nearby it which creates some turbulence, which slowing down the effective local wind speed and hence the power generation capacity.

Here is some assumption for wind speed and wind energy generation calculation and comparison.

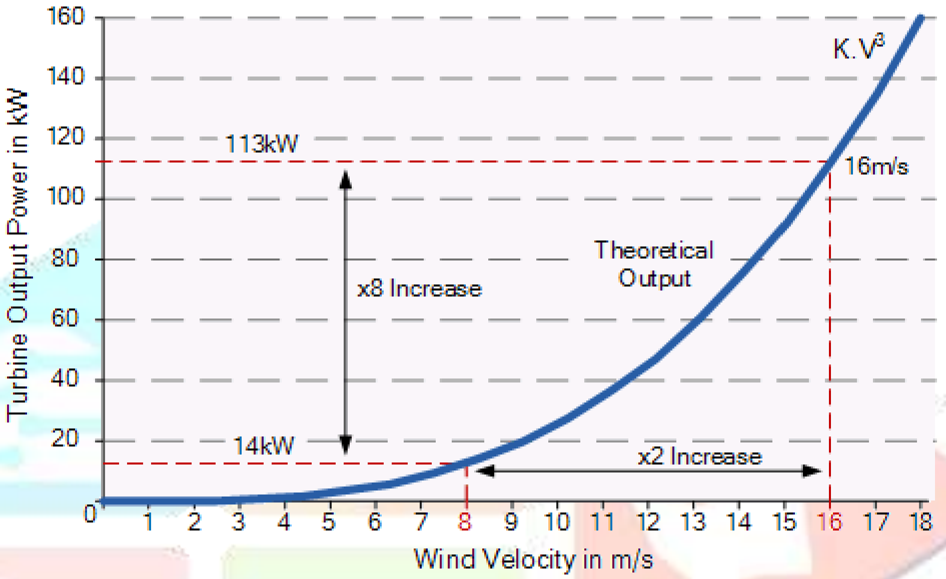
Let’s assume that we live in an area is above sea level that has an air density of 1.10 Kg/m3 and we have installed a 50 % efficient wind turbine which has a rotor blade diameter of eight (8) meters. Calculate the output power from the turbine at a wind speed of 3 meters/second, (3m/s) and again at double the velocity of 6 meters/second (6m/s).

Lets calculating power generation by wind energy at 7 meters/second

P= 0.5* *A* *Cp v^3
P=0.5*1.10* * $\pi 4^2$ * $(3)^3$ *0.50

P= 1492.128Watt = 1.4kw.

Now again calculating at 6m/s
P= 0.5*ϱ*A* *Cp v^3
P= 0.5*1.10* * $\pi 4^2$ * $(6)^3$ *0.50
P= 11937.024 w
P= 11.90 kW.



Then we can see that at a wind velocity of 3m/s the theoretical output power is calculated at 1.4kW and at 6m/s is calculated at 11.90kW. Since the wind power, P and therefore the wind energy vary with the cube of the wind velocity, (V3) twice of wind velocity from 3m/s to 6m/s results in almost eleven times (x11) the amount of available power being produced. So we can have different output while putting different values of wind speed against theoretical power output calculated from the given equation, and by which we can produce a simple power curve of any wind turbine gives an optional information towards its installation as well maintenance.

So finding a good site having good wind flow to install a wind turbine. But its become challenging to produce economical wind energy, we can perform it but need to maximize the wind speed and its output. During this case study UIT provided Wind speed histograms for this particular site to show the number of hours, days or weeks, or whatever time period is used, that the wind blew for each sampled period of time. Since the momentum of the wind mass changes from minutes to months, wind power and wind energy will also vary over the same time scale. Not only the wind speed but also increasing the rotor blade length, or increasing the height of the wind turbine above the ground will also increase the power generation. Hence one of the Objectives for storage capacity improvement can be done with this as well. We can almost increase power input around 5-7 % with some small change of design in current installed UIT base plant.

Calculating Energy Requirements form solar:

Voltage drop is given by the following formula :

$$\Delta V = b\left(\rho_1 \frac{L}{S}\cos\varphi + \lambda\, L \sin\varphi\right) \times I_B$$

Where:

V: Voltage of the DC or AC system (V)

This is phase-phase voltage for 3-phase system; phase-neutral voltage for single- Example based to the current installed plant study: using single-phase that is 230V.

ΔV : voltage drop in Volt (V)

b : lenght cable factor, b=2 for single phase wiring, b=1 for three-phased wiring.

ρ1 : Resistivity in ohm.mm2/m of the material conductor for a given temperature. At 20 Celsius degree °C the resistivity value is 0.017 for copper and 0.0265 for aluminum.

we know that resistivity increases with temperature. Resistivity of copper limits around 0.023 ohm.mm2/m at 100 °C and resistivity of copper limits to around 0.037 ohm.mm2/m at 100 °C.

Usually for voltage drop calculation according to electrical standards it is the resistivity at 100°C that is used (for example NF C15-100).

ρ1 = ρ0*(1+alpha(T1-T0)), here ρ0 = resistivity at 20°C (T0) and alpha = Temperature coefficient per degree C and T1 = temperature of the cable.

T1 : Temperature of the cable (default value = 100°C).

During study it is observed that, a wire with a correct sizing should not have an external temperature over 50°C, but it can correspond to an internal temperature of the material around 100°C.

L : simple length of the cable (distance between the source and the appliance), in meters (m).

S : cross section of the cable in mm2

Cos φ : power factor, Cos φ = 1 for pure resistive load, Cos φ< 1 for inductive charge, (usually 0.8).

λ : reactance per length unit (default value 0.00008 ohm/m)

Sin φ : sinus (acos(cos φ)).

Ib : current in Ampere

NB : For DC circuit, cos φ=1, so sin φ=0.

phase system.

Voltage drop in percent:

Where :

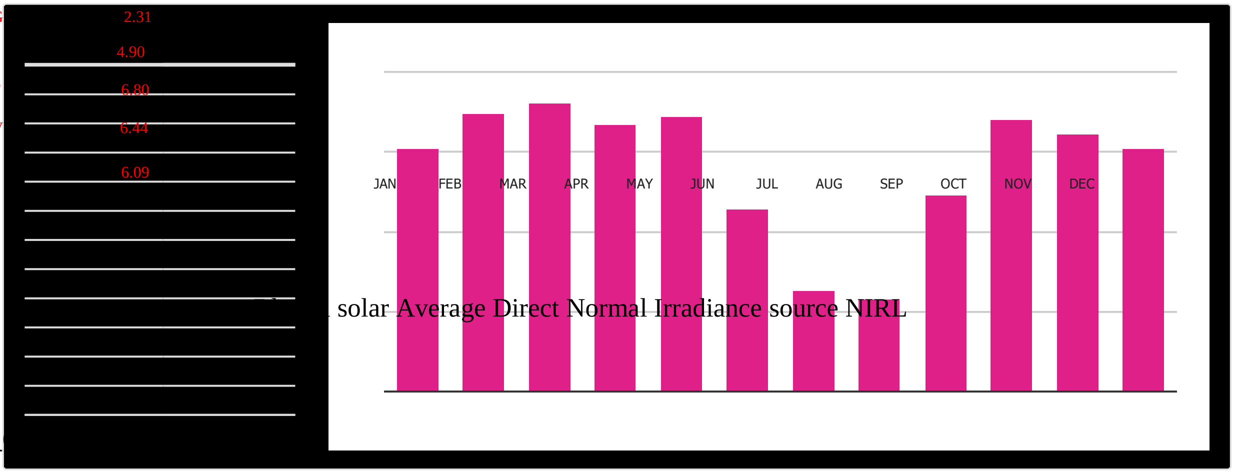
ΔU(%) = 100 x ΔU/U0

ΔU : voltage drop in V
U0 : voltage between phase and neutral (example : 230 V in 3-phase 400 V system)

Annual Average : 5.61 kWh/m^2/day

Monthly Average

JAN	6.09
FEB	6.95
MAR	7.21
APR	6.69
MAY	6.88
JUN	4.56
JUL	2.52
AUG	2.31
SEP	4.90
OCT	6.80
NOV	6.44
DEC	6.09



ENER

Energy losses in a cable is mainly due to resistive heating of the cable. It is given by the following formula :

E = a x R x Ib²

Where :

E : energy losses in wires, Watt (W)
a : number of line coefficient, a=1 for single line, a = 3 for 3-phase circuit.
R : resistance of one active line
Ib : current in Ampere (A)

R is given by the next formula :

R = b x ρ1 x L / S

b : length cable factor, b=2 for single phase wiring, b=1 for three-phased wiring. **ρ1 :** resistivity of the material conductor, 0.017 for copper and 0.0265 for aluminium (temperature of the wire of 20°C) in ohm.mm2/m.

L : simple length of the cable (distance between the source and the appliance), in meters (m).
S : cross section of the cable in mm2
NB : for direct current the energy losses in percent is equal to the voltage drop in percent.

Electricity losses:
Voltage drop and energy losses free online calculator for AC and DC Power; electrical wire drop voltage quick calculation…

BATTERIES:

Some comparisons based studies were mentioned towards improvement of plant efficiency Battery voltage and capacity in non-equilibrium. Reaction rate and polarization. Mass transport overvoltage in batteries. Activation overvoltage in batteries.Resistive drop in batteries. Secondary drop in batteries.Physical state of the electrodes.

Battery Characteristics:

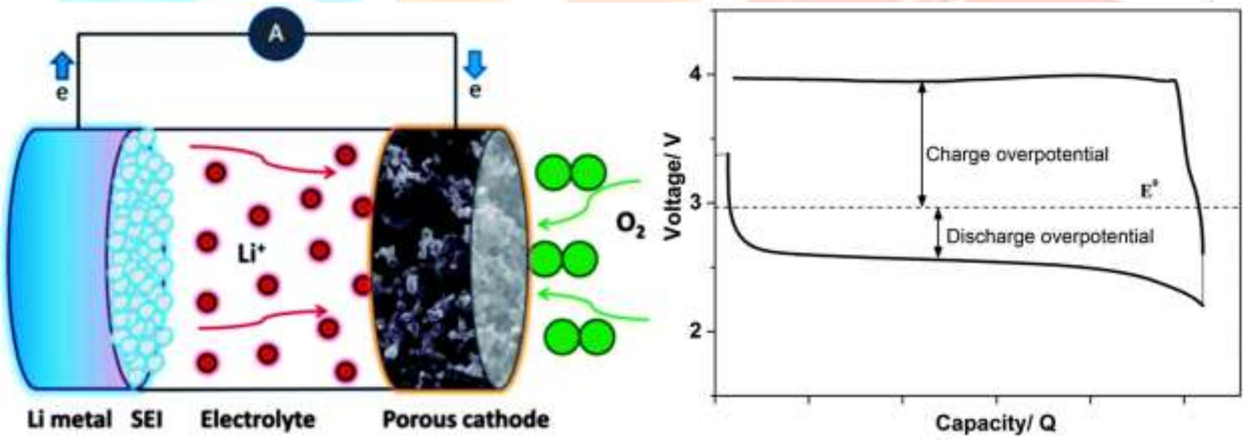
The use of batteries in solar wind hybrid systems differs from the use of batteries in other common battery applications. For current installed systems, the key technical considerations are that the battery experience a long lifetime under nearly full discharge conditions. Common rechargeable battery applications do not experience both deep cycling and being left at low states of charge for extended periods of time. For example, in batteries for starting cars or other engines, the battery experiences a large, short current drain, but is at full charge for most of its life. Similarly, batteries in uninterruptible power supplies are kept at full charge for most of their life. For batteries in consumer electronics, the weight or size is often the most important consideration. This section provides an overview of the critical battery characteristics or specifications, including battery voltage, capacity, charging/discharging regimes, efficiency, etc.
We know that battery capacity is measured in Amp Hours. You need to convert this to Watt Hours by multiplying the AH figure by the battery voltage (e.g. 12V). Using this simple formula to calculate conversion of amp to watt
X (Battery size in AH) x Y (Battery Voltage) = Z (Power available in watt hours
For a 15AH, 12V battery the Watt Hours figure is 15(X) x 12(Y) = 180 WH (Z)

This means the battery could supply 180W for 1 hour, 120W for 2 hours or even 2w for 120 hours, which clearly shows that the more energy consumptions, makes fast to discharging battery.

Li-salts for re-chargeable batteries

Early studies on lithium batteries with metal anodes in the 1970–1980's were limited to Li-salts with a few anions like hexafluoroarsenate (AsF_6^-), perchlorate (ClO_4^-), hexafluorophosphate

(PF_6^-), tetrafluoroborate (BF_4^-), and trifluoromethanesulfonate or triflate (Tf) ($CF_3SO_3^-$). A schematic with the chemical structures of these and several other anions discussed in this work is presented in Fig. With the development of LIBs it became clear that $LiAsF_6$ and $LiClO_4$ were inappropriate for commercial cells, due to safety and toxicity concerns. Similarly, the relatively low conductivities of electrolytes based on LiTf made also this salt less popular. Later, with the commercialization of graphite anodes, the $LiPF_6$ and $LiBF_4$ became the most popular Li-salts as they, together with solvents such as ethylene carbonate (EC), could form a solid electrolyte interphase (SEI) on graphite, making rechargeablelithium batteries commercially viable. Ultimately, $LiPF_6$ became, and still is, the dominant salt in commercial LIBs. This success is not because $LiPF_6$ is considered "the best" salt in all categories. In fact, $LiPF_6$ is not the leading salt in any of the properties important for batteries like: ionic conductivity – relatively good, sensitivity to hydrolysis – poor, or thermal stability – poor, but its success is due to the ability to provide the best balance of these and other properties, as well as the formation of a proper SEI on the graphite anode and a protective layer on the aluminum cathode current collector. This is a clear example showing the complexity of the criteria the Li-salt should fulfill with respect to the several different components of a cell. For specific applications, other salts are often competitive, *e.g.* $LiBF_4$ has shown to improve the performance of LIBs at high (50–80 °C) and low temperatures (−20 °C),but its overall drawback is moderate ionic conductivity in the resulting electrolytes.



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CONCLUSION:

From the studies and observations of wind solar hybrid system of 1.6kv capacity, it has been noted that plant needs a specialized maintenance and also need to improve its design both for wind and solar. which is costly, so one other operation can be done with simply replace Lead acid battery which is currently installed to the plant of UIT can be rated to the 50% of its own rated power, it can be cleared with an example, if we have a 10Ah lead acid battery then we can just use its 50% of capacity, because such product have its own rating of 50%. In other hand in current hybrid plant, if

Li-ion battery can be used instead of Lead acid batteries then because of rated power of Li-ion which is 80%, means 30 % more than the typical lead acid batteries can automatically increase its storage capacity 50% to 80%. This will for sure improve efficiency of current hybrid solar wind plant in UIT Bhopal plant.

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