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Design And Analysis ofA Roof Top Grid Connected To PV-Wind Hybrid System at SVKM's NMIMS Navi-Mumbai Campus: A Case Study

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ABSTRACT: *In this paper, designing and decision support analysis of a grid connected, solar PV-Wind Hybrid plant, for meeting the daily energy demands of SVKM's NMIMS Navi-Mumbai campus (Lat. 19.04^o N, Lon. 73.06^o W) was studied and analyzed. The proposed system was designed after investigating the detailed feasibility for financial parameters. The study focuses on the use of solar PV-Wind hybrid plant to be located on the roof top of the institute building, to cater the daily electricity demand. The hybrid system of wind and solar complement each other by overcoming the weakness of each other and creates a balanced approach for efficient energy production. Life cycle assessment parameters which affect the feasibility of the proposed system are also discussed, i.e. energy pay-back time, capacity utilization factor and life cycle conversion efficiency. The pay-back period is found to be 3.2 years which is excellent compared to other such systems available.*

Keywords:*PV-Wind Hybrid, life cycle assessment, payback period, solar, grid connected.*

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I. INTRODUCTION

In recent years, there has been an appreciable interest in the utilization of PV wind hybrid system due to concerns about environmental issues associated with use of conventional fuels, rising fuel price and energy security. Renewable energy systems that take advantage of energy sources that won't diminish over time and are independent of fluctuations in price and availability are playing an ever-increasing role in modern power systems [1]. There are compelling reasons to believe that the traditional system of large, central power stations connected to their customers by hundreds or thousands of miles of transmission lines will likely be supplemented and eventually replaced with cleaner, smaller plants located closer to their loads [1]. Not only do such distributed generation systems reduce transmission line losses and costs, but the potential to capture and utilize waste heat on site greatly increases their overall efficiency and economic advantages [1]. Moreover, distributed generation systems offer increased reliability and reduced threat of massive and widespread power failures [2]. This paper presents a detailed decision support analysis of a grid connected PV-wind hybrid system to cater the daily demand of electricity consumption at SVKM's NMIMS Navi Mumbai Campus.

For different regions and locations, climatic conditions, including solar irradiance, wind speed, temperature and so forth, are always changing. Thus there exist instability shortcomings for electric power production from PV modules and wind turbines [3]. The global PV installed capacity at the end of 2015 was estimated as 227 GW as compared to 3.4 GW in 2004 (Renewables, 2016). This shows a tremendous growth of solar PV installation for power generation over the last ten years. During 2015, India occupied 5th position in the world by adding 4% (2 GW) of solar PV installation resulting a total capacity over 5 GW (Renewables, 2016). Under the Jawaharlal Nehru National Solar Mission of New and Renewable Energy Govt. of India has targeted the installation of 100 GW at the end of year 2022 (MNRE). As a result many sites with abundant potential of solar and wind are explored and their feasibility analysis has been carried out. The grid connected rooftop solar PV system along with Wind system provides a viable option for meeting the demand at a given site also it offers to feed the surplus amount of generation to the grid. The author had attempted an assessment of a Solar PV plant for girl's hostel of MNIT University in Jaipur city and examined its financial viability with parameters associated and real time market prices. Their study shows that the energy payback time for the plant comes out to be 8.24 years with life cycle conversion efficiency of 0.072. Also the carbon credits that can be earned from the plant was results as 15 281 tCO2e which worth of $10,300 at a price of $0.67/Credit [4]. In this paper a 20 kWp on site PV-wind hybrid plant is designed along with its financial consideration.

II. ANALYSIS OF LOAD DEMAND

A detailed audit of each section in the institute was carried out to segregate and understand the load demand. The following tables give the complete details of different equipment's and their operation timings. The total energy needed to be supplied by the proposed system is found to be 189.2 kWhr per day.

Table 1 Energy consumption at SVKM's NMIMS Navi Mumbai Campus

Type of load	quantity	Total capacity in watt	Hours of operation		Energy consumption (Whr)
			Day	Night	
Tube light (Indoor)	150	33	10	0	49500
Tube light (outdoor)	50	33	8	10	33000
LED lamps	200	10	10	0	20000
Fan	10	40	8	0	3200
Computers	100	90	8	0	72000
Printer	10	150	1	0	1500
Audio System	10	150	4	0	6000
Projectors	10	200	2	0	4000
Total Consumption per day					189200

Based on the above data detailed load segregation was performed to understand critical load and their demands.

Table 2 Segregation of load demand

Location	Tube light	LED lamps	Fan	Computers	Printer	Audio system	Projectors
Classroom	35	40	2	10	0	10	8
Labs	35	40	2	60	2	0	2
Admin Area	15	20	2	20	8	0	0
Corridors	35	40	0	0	0	0	0
Washrooms	5	5	0	0	0	0	0
Stair case	5	5	0	0	0	0	0
Workshops	20	50	4	10	0	0	0
Total load	49500	33000	20000	72000	1500	6000	4000

III. SITE POTENTIAL AND METHODOLOGY

3.1Site Information: The proposed site is located in the state of Maharashtra, the coordinates, the annual global GHI along with annual average wind speed and annual average temperature are studied and mentioned below.

Table 3 Details of the proposed site

Site name	SVKM's NMIMS Navi Mumbai campus
Coordinates	19.04^{o} N, 73.06^{o} E
Elevation	8 meters
Annual Global GHI	5.6 kWh/M^2/day
Annual average wind speed	3.2 m/s
Annual average temperature	26.99

Fig. 1 Geographical layout of the proposed sit

3.2 Wind Profile: The wind data for the proposed site was collected from Ministry of New and renewable Energy Sources. The graphical representation of the data illustrates that the average wind speed at the proposed site is nearly 2.5 m/s.

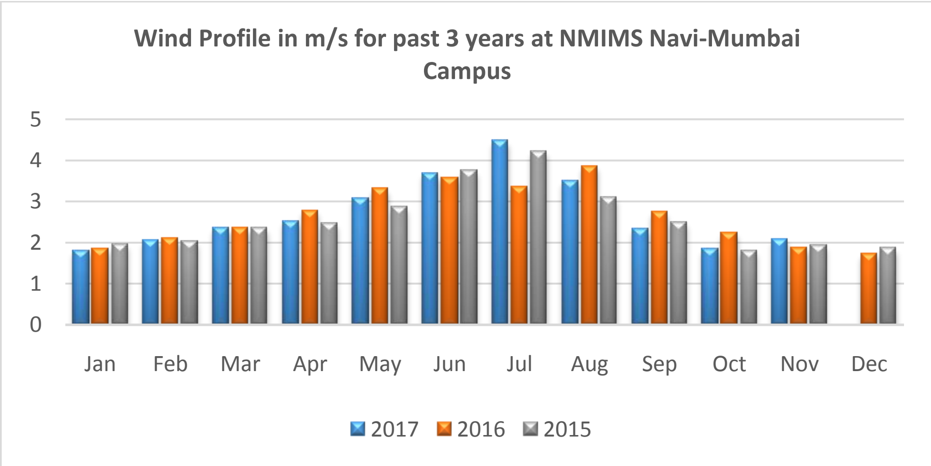

Fig 2. Wind Profile in m/s for past 3 years at NMIMS Navi-Mumbai Campus

3.3 Solar insolation data at the site: The solar insolation data for the proposed site was collected from the NASA portal. The graphical representation of the data illustrates that the average solar insulation at the proposed site is nearly 5.67 KWh/m^2/ day.

Table 4 Solar radiation data (KWh/m^2/ day)

January	6.51
February	7.06
March	6.33
April	6.19
May	6.86
June	3.29
July	1.60
August	1.72
September	3.24
October	6.20
November	6.43
December	6.35

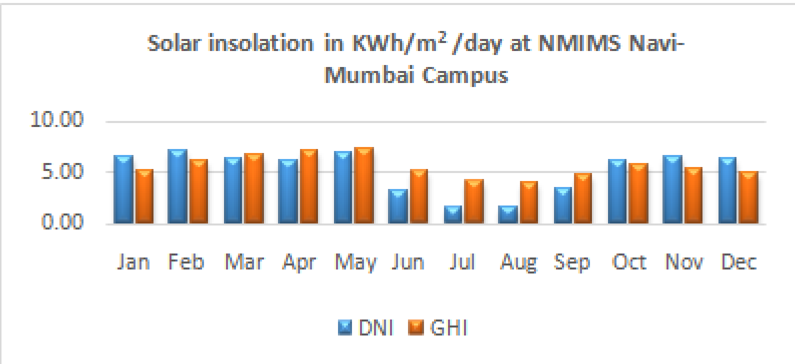

Fig 3. Solar insolation in KWh/m^2 /day at NMIMS Navi-Mumbai Campus

3.4 Comparison of Wind and Solar Potential: The comparison of wind and solar potential at the proposed site is illustrated graphically in fig 4 below. It shows that the solar and wind power complement each other and creates a balance approach for efficient energy production.

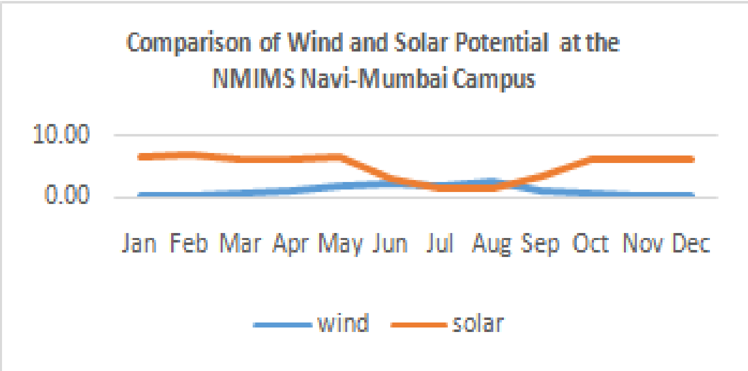

Fig 4. Comparison of Wind and Solar Potential at the NMIMS Navi-Mumbai Campus.

3.5 Methodology:

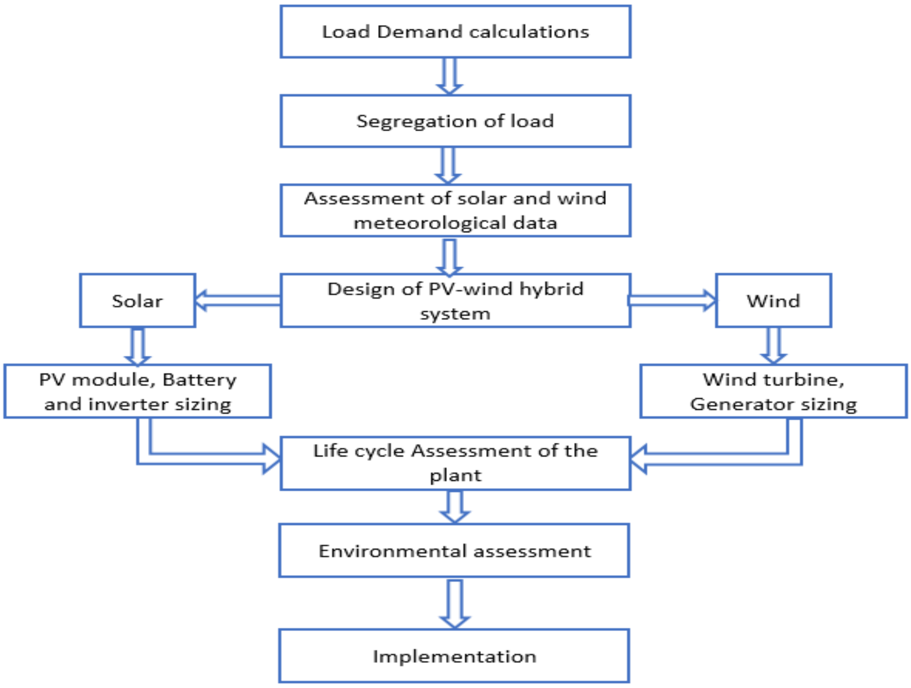

Fig 5. Process flow for Design and Assessment of the Wind – PV hybrid plant

IV. DESIGN SPECIFICATION AND CALCULATIONS

4.1 The Wind Solar Hybrid plant Specification

4.1.1 PV module Specification: The TS 250 (TATA) is a 60 cell multi crystalline solar photovoltaic module manufactured in India. The modules are enhanced to moisture ingress owing to its unique back sheet design. The approximate efficiency for the TS 250 module is about 15%. The specifications for the TS 250 module are listed below [8].

Table 5 Specification for TS 250 Module

Module Type	TS 250 (TATA)
Peak power output Watt (P_{max})	250
Current at peak power output amp (I_{max})	8.16
Voltage at peak power output (V_{max})	30.7
Short circuit current (I_{sc})	8.58
Open circuit voltage (V_{oc})	38.1
Area	1.66
Cell efficiency	15
Power tolerance	±2.5

4.1.2Wind Turbine specification:

Table 6 Wind Turbine Specification [7]

Rated Power (P) at V= 3m/s kW	2
Velocity of wind (V) m/s	3
Overlap ratio (β)	0.15
Inner radius for rotor blade (R) mm	175
Rotor Overlap (a) mm	52.5
Rotor Diameter (D) mm	657.5
Height of Blade (H) mm	1620
Area of Turbine (A) mm^2	1064
Rotor Aspect ratio (α)	1
Density of air (ρ) kg/m^3	1.2
Density of PVC kg/m^3	1420
Blade thickness (t) mm	5

4.1.3Variation in cell efficiency with temperature: Solar cell performance decreases with increase in temperature, which leads to decrease in overall efficiency as well as the power output. The following table justifies that the modified efficiency is less than the standard efficiency during the months with higher temperatures (>STC).

Table 7 Variation in cell efficiency with temperature [5].

Month	T_{avg}	T-Tref	B(T-T_{ref})	1- B(T-T_{ref})	Modified Efficiency
January	23.5	-1.5	-0.0807	1.08	0.16
February	24.1	-0.9	-0.04842	1.05	0.16
March	26.6	1.6	0.08608	0.91	0.14
April	28.8	3.8	0.20444	0.80	0.12
May	30.3	5.3	0.28514	0.71	0.11
June	29.2	4.2	0.22596	0.77	0.12
July	27.5	2.5	0.1345	0.87	0.13
August	27.2	2.2	0.11836	0.88	0.13
September	27.3	2.3	0.12374	0.88	0.13
October	28.1	3.1	0.16678	0.83	0.12
November	26.6	1.6	0.08608	0.91	0.14
December	24.7	-0.3	-0.01614	1.02	0.15

4.2 Calculations

4.2.1Panel generation factor [6]

The panel generation factor is essential parameter for developing a solar PV plant. For the proposed location it was found to be 5.56 KWh/m^2.

$$Panel generation factor for solar PV = \frac{Average solar radiation}{standard test condition}$$

$$= \frac{5.56}{1} = 5.56$$

4.2.2Energy requirement from the solar panel[6]

In order to calculate the total energy requirement, compensation factor of 1.3 is considered. The compensation factor deals with the system losses.

$$Energy requirement from the solar panel = (Energy demand \times loss compansation factor) = 200 \times 1.3 = 260\ kWh/day$$

4.2.3Watt peak rating for solar system[6]

The total watt peak rating of PV modules is derived from the above two factors and it was found to 47 kWp.

$$Total watt peak rating of the solar system = \frac{Energy requirement from the solar panel}{Panel Generation factor} = \frac{260}{5.61} = 46.3 \approx 47\ kWp$$

4.2.4Number of modules [6]

For the analysis TATA TS 250 solar module is considered. The total number of modules required for the proposed plant are found to be 188 modules.

$$Number of Modules = \frac{Total watt peak rating of the solar system}{Rated output of TS250\ solar panel} = \frac{47000}{250} = 188\ Modules$$

4.2.5Battery Sizing:

The total number of batteries depends upon their individual capacity. For this analysis we have considered Luminous INVERLAST - ILTT 26060 (/www.luminousindia.com).

Table 8 Specification of Luminous INVERLAST - ILTT 26060

Parameter	Value
Rated battery voltage	48 V
AH rating	220 AH
Technology	Tall Tubular
Boost charging	Starting: 22.2 A; Finishing: 11.1 A
Warranty	60 Months
life	5-7 years
Cost	15,200 Rs

$$Capacity of Battery requiered = \frac{Wh requiered \times days of autonomy}{Voltage \times (1 - DOD) \times efficiency} = \frac{200000 \times 1}{48 \times 0.6 \times 0.9} = 10630\ AH$$

$$Number of Batteries = \frac{Battery capacity}{Single battery capacity} = \frac{10630}{220} = 46\ numbers$$

4.2.6Total size of inverter:

The power output of the solar PV panel is DC in nature so it is essential to use a inverter, to provide constant voltage and frequency AC supply. The inverter size should be 25% – 30 % bigger than the total watt requirement [6].

$$Size of inverter = 47 \times 1.25 = 58.75 \approx 60\ kW$$

Table 9 Specification of Inverter

Model number	PVI 60kW
DC Input Voltage	600 VDC
Maximum input operating current	202 Amps
Output system	3-Ph 4-wire system
Efficiency	96%
Safety listing and certification	UL 1741/IEEE 1547, IEEE 1547.1, IEEE 62.41.2, IEEE 62.45, IEEE C37.90.2, CSA C22.2#107.1, FCC part 15 B
Warranty	5 Years

4.2.7 Array Sizing

The sizing of array indicates the series parallel combination of the PV modules to get the desired voltage for the input to the inverter[6].

$$Size of an array = \frac{V_{max}\ of inverter}{V_{oc}\ of Solar panel} = \frac{600}{38.1} = 16\ modules$$

All the modules are connected in series so that,

$$the input voltage to the inverter = 30.6 \times 16 = 491.2\ Volts$$

Table 10 Total cost estimate for the proposed plant

1	Solar panel	18,80,000
2	Wind Turbine	2,00,000
3	Battery	6,99,200
4	Inverter	14,64,000
5	Miscellaneous cost	45,000
	Total	42,88,200

4.3 Financial Analysis [6]:

- The amount saved in the form of monthly electricity bill $= 260 \times 14 \times 30 = 109200$

- The amount saved on yearly basis$= 109200 \times 12 = 13{,}10{,}400$

Payback period $= \frac{4288200}{1310400} = 3.2\ years$

V. CONCLUSION

This paper has attempted an assessment of a PV-Wind Hybrid System for SVKM's NMIMS, Navi Mumbai Campus and examines its financial viability with parameters associated and real time market prices. The findings of presented study are concluded as follows:

- The 47 kWp system designed for the campus requires 188 modules of solar panels (45 kW) and 2 kW of wind turbine to supply electric energy to the campus.
- The annual energy generation from the hybrid system can fulfill the demand under all the weather conditions.
- The hybrid system can help us to reduce the dependence on conventional grid connected supply and reduce the greenhouse gas emissions.
- The payback period for the proposed hybrid system is found to be 3.2 years, which is low considering the financial investment and annual saving on electricity bills for the next 20 years (i.e. The Life Cycle of the plant.)

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REFERENCES

[1]. Gilbert Master, Renewable and Efficient Electric Power Systems(John Wiley & Sons, 03-Jan-2005).

[2]. Nabil A. Ahmed et. al., Power fluctuations suppression of stand-alone hybrid generation combining solar photovoltaic/wind turbine and fuel cell systems, Energy Conversion and Management, Volume 49, Issue 10, October 2008, Pages 2711-2719.

[3]. Hongxing Yang, Lin Lu & Wei Zhou, A novel optimization sizing model for hybrid solar-wind power generation system, Solar Energy 81, 2007, 76–84.

[4]. Rahul Khatri, 2016, Design and Assessment of Solar PV Plant for Girls Hostel (GARGI) of MNIT University, Jaipur City: A Case Study,Energy Reports 2, 89-98.

[5]. SwapnilDubey et.al. 2013, Temperature Dependent Photovoltaic Efficiency and its Effects on PV Production in the World - A Review,Energy Procedia33, 311-321.

[6]. B.H. Khan, Non-Conventional Energu Resources, McGraw Hill Education, 2017.

[7]. Aditya S. Kasar et. al., Design and Analysis of 5 KW Savonius Rotor Blade, International Journal of Advances in Management Technology & Engineering Sciences, Vol. II, Issue 10 (I), July 2013.

[8]. PunitRatnani et.al., Design of Solar PV Source for an Education Complex, National Journal on Electronic Sciences and Systems, Vol. 5, Paper No. 02, 2014.

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