International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Review Article)

High gain super lift Luo converter for hybrid energy management systems

KARTHIKEYAN K *, JAYANTHI G ANBAZHAGAN S and GOKULAKRISHNAN R

Electrical and Electronics Engineering, Mahendra Engineering College, Namakkal, India.

International Journal of Science and Research Archive, 2024, 13(01), 1318–1331

Publication history: Received on 09 August 2024; revised on 20 September 2024; accepted on 23 September 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.13.1.1757

Abstract

Recently, there has been a resurgence of interest in the development of alternative energy supplies due to rising fossil fuel prices and issues about the effects of greenhouse gas emissions on the environment. Today's demand is the design of a hybrid electric power generation system that uses solar and wind energy for remote places. This paper presents the design of an optimized hybrid renewable energy system consisting of a photo voltaic wind turbine (savinous type) with a battery and a super lift LUO converter.

A solar PV module with an intelligent inverter facilitates the tracking of the maximum power point and the implementation of a battery charge controller for greater battery lifespan as well as reliable performance. Higher power output and clean energy are available from the hybrid power generation system, which combines innovative techniques with solar and wind power.

Keywords: Luo converter; HRES; Hybrid; PV; Savinous; VAWT; Battery

1. Introduction

An inverter, a battery, a wind turbine, solar panels, and other parts make up a hybrid renewable PV-wind energy system. Any additional electricity is saved in the battery until it is fully used up when the solar and wind energy sources are producing sufficient electricity. When the PV-wind renewable energy sources are unable to meet the demand for power, the battery then turn on and continues to do so until the storage capacity is consumed. The system's various components contribute to how it functions and what its maximum output is for each one.

This work develops a Perturb and Observe (Hill Climbing Algorithm) controller for a hybrid PV/wind electric power system using MPPT. Intelligent techniques such neural networks, fuzzy logic, and expert systems have become vital in the design of smart grid controllers due to the evolution of solid-state electronics and power systems. Potential tools for developing and erecting fault detection controllers in advanced smart grids (SGs) are provided by these techniques. In the industrial setting, the application of intelligent techniques has grown substantially in the last several years. Digital grid energy networks require performance control, user contact, and the integration of renewable energy.

Power variations brought on by unbalanced loads can induce pulsed torque and increased reactive power at the input generator. By combining several energy sources to preserve service even when one or more are dormant, hybrid energy systems offers a way to lower the need for energy storage. This may result in a smaller battery, which is advantageous from a cost standpoint. When used separately, solar and wind energy—two erratic renewable energy sources—may not be dependable. However, the total amount of solar and wind energy is still comparatively constant in many places. Combining these two renewable energy sources can increase system reliability and maintain or slightly lower system prices, depending on local conditions.

*Corresponding author: KARTHIKEYAN.K

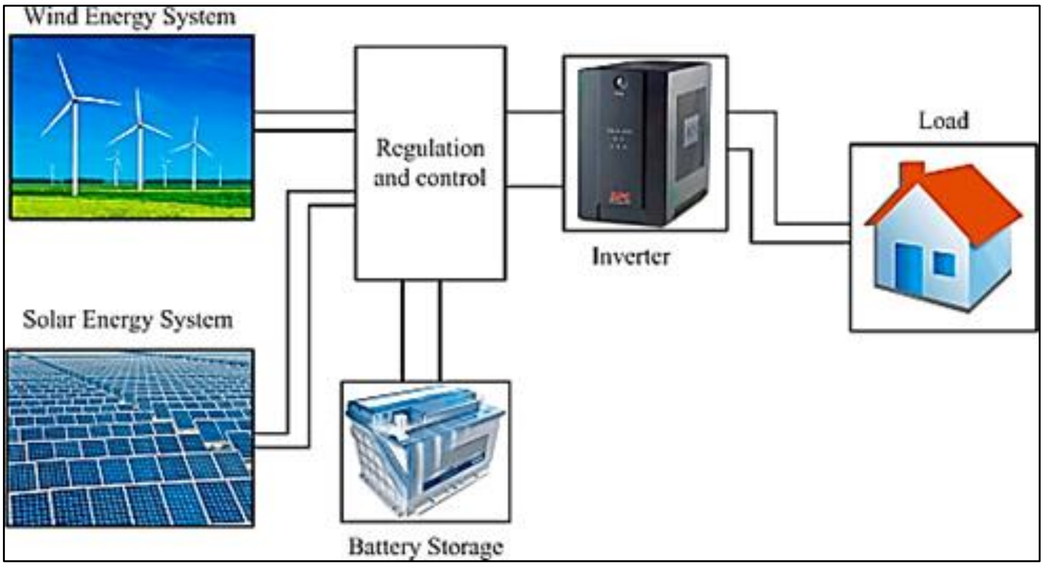

Figure 1 Basic Working flow of Solar Wind Hybrid

The hybrid system generates power using both solar and wind power equipment. The PV system incorporates a maximum power point tracking system along with PV modules to capture solar energy from the surrounding environment. With this method, incident light is transformed into electricity. To maximize power generation from the PV modules, the maximum power point tracking system implements the Perturb & Absorb the methodology. Converters are also utilized to change alternating current into direct current.

The generator, converter, gearbox, and wind turbine make up the wind energy system. The wind turbine converts the kinetic energy of the wind into mechanical energy, which is then converted into electrical energy by the generator. To optimize the system's performance, an MPPT method is implemented. The impact of the erratic nature of solar and wind resources is lessened with this strategy, which optimally integrates the two resources. This is especially crucial for independent systems. Actually, a more and more effective choice for standalone systems is the combining of renewable energy output with battery storage and diesel generator backup systems. Even during peak times, the system can manage the load because of to this hybrid configuration.

2. Literature Review

Numerous studies on the hybrid power generation system integrating solar and wind power have been performed. Some instances from the literature pertaining to different systems' categories are as follows:

Celik A.N. [8] developed a novel optimization technique for the techno-economic evaluation of standalone small-scale hybrid photovoltaic-wind energy systems. When combined optimally, the hybrid photovoltaic and wind energy systems may perform better than when utilized independently. It has been illustrated by a single PV system that the size and storage capacity of the batteries have a significant effect on the performance of the wind system.

Makbul A.M. Ramli et al. [4] A case study model on the combined wind and solar approach was presented, along with a techno-economic energy analysis for the applied method. The goal of the study is to identify the most economical method for developing an electric vehicle with a hybrid system and various categories of features.

Vikas Khare et al.[5] presented and reviewed the HRES. Numerous HRES-related issues, including ideal sizing, feasibility analysis, modeling, control parameters, and reliability, had been the focus of the study that was presented.

Yahia Bouzelata et al. [6] reviewed the hybrid solar and wind energy system's optimal setup and performance. Energy is produced by the WECS double-fed induction generator, which shows improved power quality in the power electronics.

Palash Jain et al. [7] The principles guiding the small-scale VAWT blade pitching include performance prediction and variable amplitude. It has been established that the blade pitching amplitude varies with wind and tip speed ratio after completing the various design obstacles.

J. Vignesh et. al., [23] VAWT technology is beginning to be used by small producing facilities, especially in urban locations where wind resources are still undeveloped. The omnidirectional guiding vane can greatly increase power, speed, and torque, with regard to research. Using Wind VAWT in a PV hybrid power generating system can be a solution in many cases because it is less expensive for utilizing this system than the two separate technologies.

Hafsa Murtaza et. al., [25] The primary intention was to design a small-scale vertical-axis wind turbine that works in tandem with a solar panel. The data that has been analyzed indicates that vehicles on highways are capable of producing enough energy to light lamps and boost output electricity power in remote areas.

M. Rambabu et. al., [30] An improved and more effective method of producing power is to integrate energy sources with vertical axis wind turbines and solar energy systems. In summary, this system combines two energy sources so that, are supposed to one stop producing electricity, the other will carry on and keep the load powered continuously. Renewable energy sources are used to create electricity continuously and uninterruptedly. Additionally, they lessen global warming and pollution.

3. Hybrid Power Generation with Super Lift Luo Converter

A mix of unconventional energy sources is referred to as "hybrid" energy. The first source of energy, photovoltaic energy, is created by converting temperature and irradiance into solar energy. The second power source, wind power, produces mechanical energy for electricity through the use of wind turbines. The input voltage for this system ranges from 12V to 24V, depending on factors such as sunlight, temperature, and load on the solar panel. The output voltage can vary between 10V to 24V, depending on the state of charge and strength of the battery system. To accommodate this range of input and output voltages, a buck converter is chosen as the interface converter for the system using MPPT Based Perturb and Observe (Hill Climbing Algorithm). If the total current generated by the PV and wind generators is less than what is needed by the load, the energy deficit is supplemented by the storage system and the controller will discharge the battery. To optimize the power output from a non-linear energy source like a solar panel, MPPT algorithms are utilized. The Wind-Solar Hybrid System is capable of generating electricity that can be used to charge batteries, and with the use of an inverter, can power AC appliances.

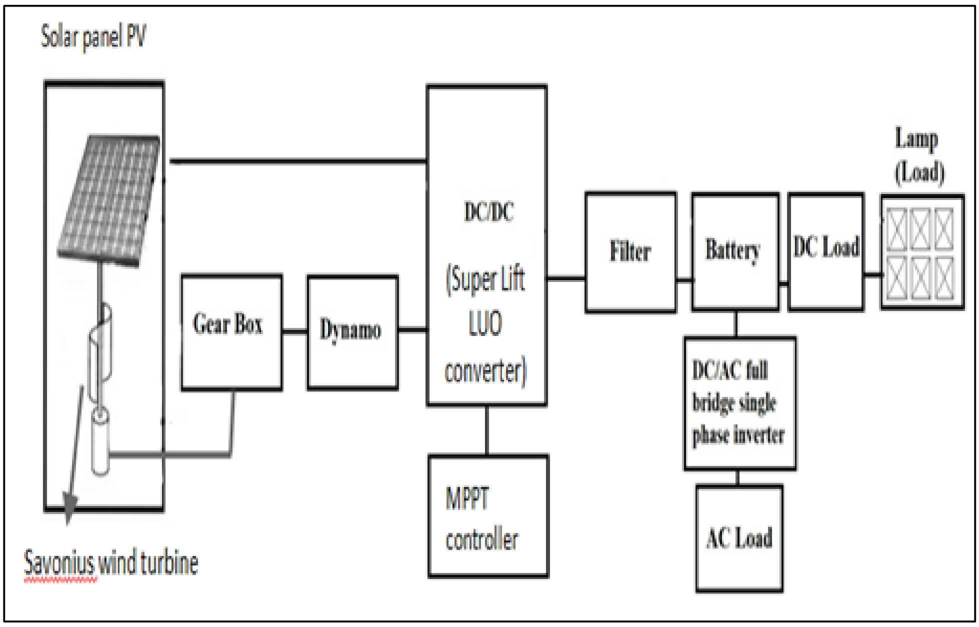

Figure 2 Hybrid Power Generations with Super Lift Luo Converter Block Diagram

For the Luo converter to function, energy storage is provided by inductors D1 and D2. These inductors store energy in magnetic fields while the converter operates. Inductor L1, which serves as a current regulator, is essential to preserving a steady output current. This function makes sure that irrespective of how much the input voltage or load conditions fluctuate, the output current remains constant.

In applications like some power supply systems that need precise output current executives, this stability is very important. The significant efficiency of the Luo converter can be attributed to its ability to maintain a steady input current. By maintaining a constant input current, the converter may work more effectively while producing less heat and less energy loss. In the circuit, diodes D1 and D2 have two uses. They serve as filters, mitigating potential waves in voltage and current that can develop while the converter is performing.

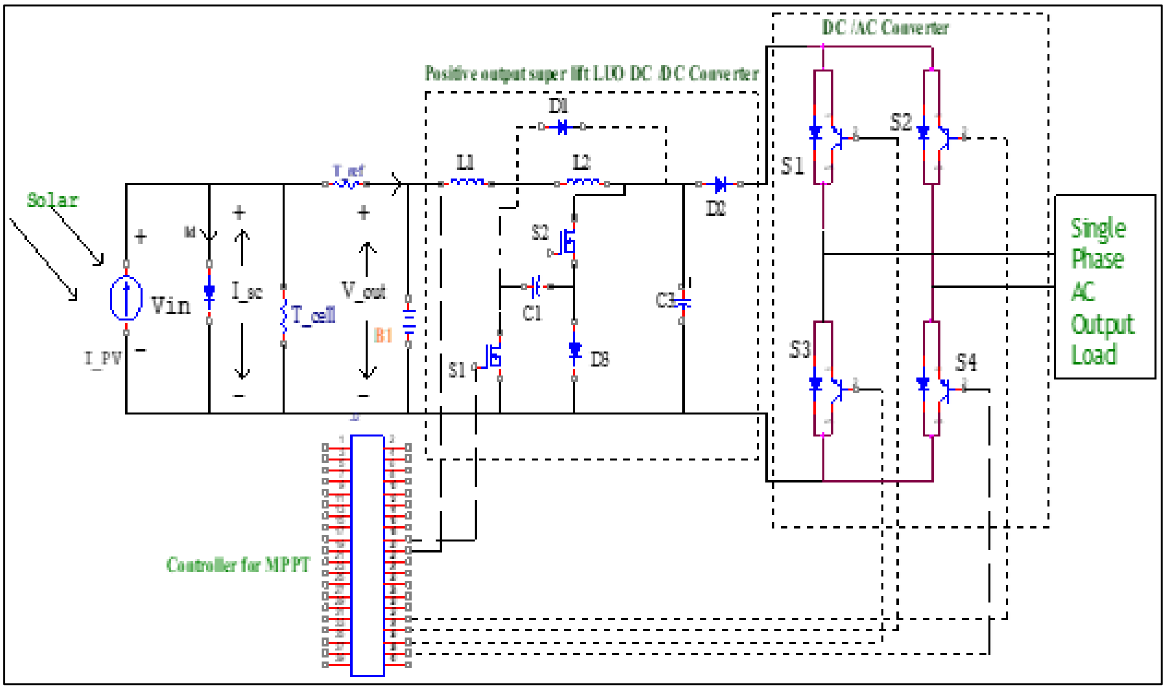

Figure 3 Hybrid Power Generations with Super Lift Luo Converter Circuit diagram

This filtration contributes to a mostly stable output. Second, they facilitate energy transfer and storage in the inductors by taking part in the energy storage process. The Luo converter is recognized for its adaptability in voltage regulation; it can operate with the same polarity output as a buck converter, which lowers voltage, or as a boost converter, which increases voltage. The duty cycle of the switching elements (usually switches or transistors) in the circuit determines the particular mode, which can be either boost or buck converter.

4. Hardware Implementation

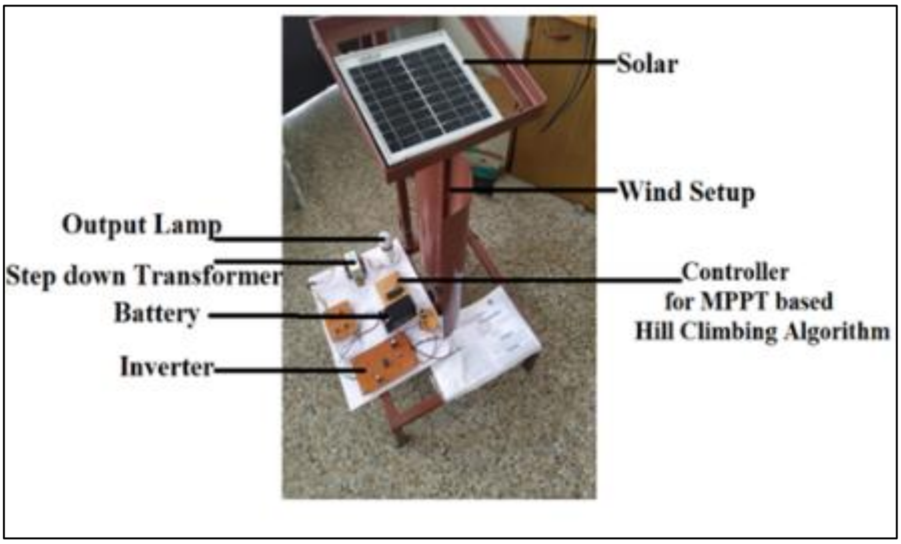

Figure 4 Hardwaree Kit

4.1. Hardware Specifications

Table 1 Hardware Specification

Hardware	Specification	Input Ranges	Output Ranges
Solar panel (Power Source 1)	Input source	11.25V	13.5V
Wind (Savinous Type Blade) (Power Source 2)	Input source (Dynamo + Gear)	11V	12V
Super Lift LUO	Converter	0-24V	32V
Transformer	Step down	230V	110V
Rectifier	Input power	110V AC	230V DC
Battery	Input power	12V	7.2A
Microcontroller (For MPPT tracking)	PIC (16F877A)	5V DC	5V DC
Inverter	Output power	110V DC	110V AC
Transformer	step-up	110v AC	230v AC
Load (AC LOAD)	Load	230V	4A

5. Result Analysis

Table 2 shows the output result of sunlight intensity, voltage, current, power and with respect of time for solar panel.

Table 2 Output Result for Solar Panel System

Time	Sunlight Intensity (w/m2)	Voltage (V)	Current (A)	Power (W)
7AM	320	9.6	0.12	1.15
8AM	456	10.4	0.16	1.66
9AM	524	12.2	0.22	2.68
10AM	626	12.7	0.28	3.55

11AM	790	13.2	0.32	4.22
12PM	842	13.8	0.36	4.96
1PM	892	14.3	0.42	6.01
2PM	844	13.6	0.38	5.16
3PM	725	12.8	0.37	3.96
4PM	653	12.4	0.29	3.59
5PM	692	11.2	0.25	2.81
6PM	480	10.5	0.19	2.01

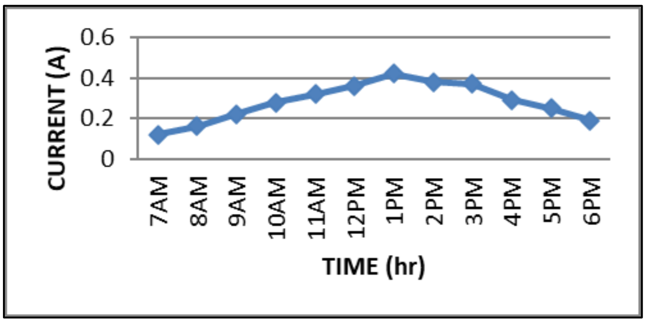

Figure 5 Output Current Wave form of PV

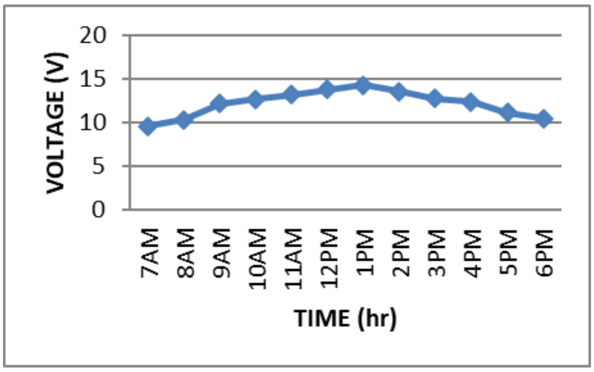

Figure 6 Output Voltage Wave form of PV

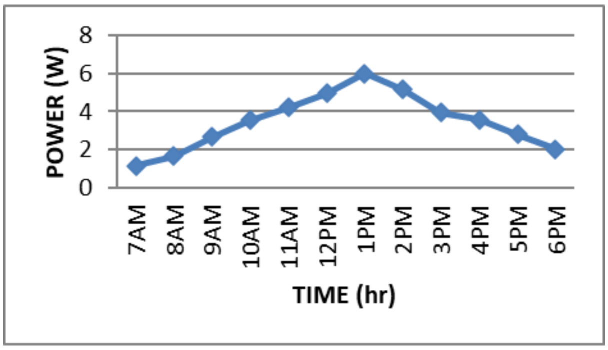

Figure 7 Output Power Wave form of PV

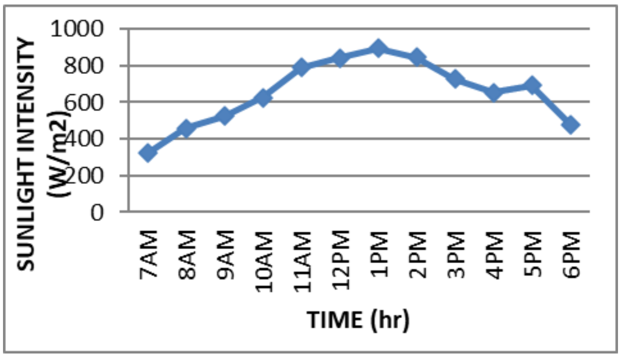

Figure 8 Sunlight Wave form of PV

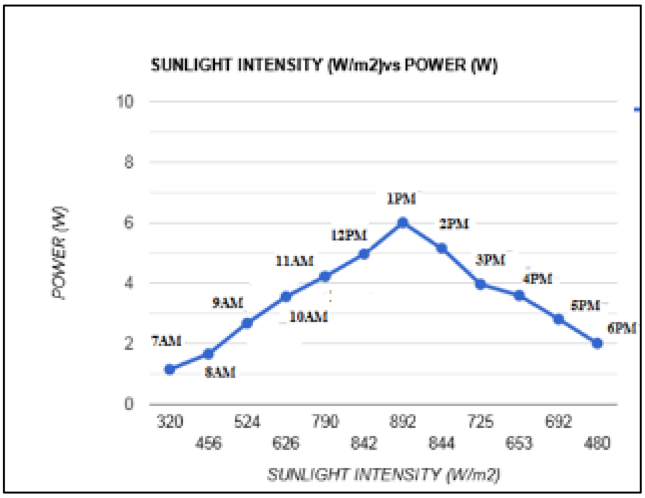

Figure 9 Output Wave form of Power and Sunlight of PV

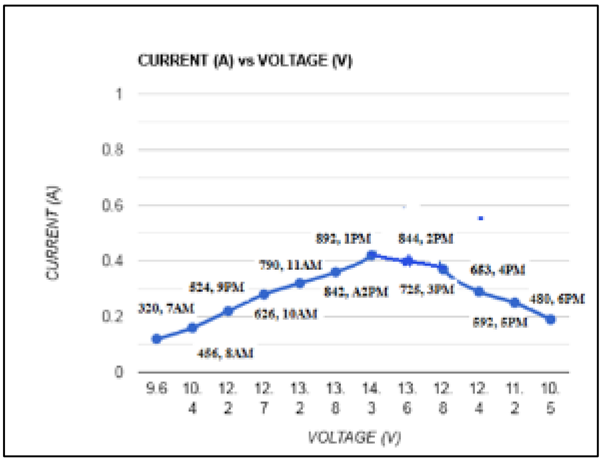

Figure 10 Output Voltage and Current Wave form of PV

Table 5.2 shows the output result of wind speed, rotor speed, dynamo speed, voltage, current, power and with respect of time for wind system.

Table 3 Output Result for Wind System

Time (hr)	Wind Speed (m/s)	Rotor Speed (Rpm)	Dynamo Speed (Rpm)	Voltage (V)	Current (A)	Power (W)
7AM	5.2	56	114	13.2	0.54	7.12
8AM	4.8	49	105	12.6	0.51	6.42
9AM	4.4	46	98	12.2	0.46	5.61
10AM	3.9	40	86	11.4	0.47	4.78
11AM	3.5	37	77	10.2	0.38	3.87
12PM	3.1	33	70	9.7	0.35	3.39
1PM	2.8	30	66	9.8	0.37	3.62
2PM	2.9	32	64	10.4	0.41	4.26
3PM	3.4	36	76	11.3	0.48	5.42
4PM	3.7	40	88	11.5	0.51	5.51
5PM	4.2	45	94	12.5	0.53	6.62
6PM	4.9	52	110	13.1	0.55	7.20

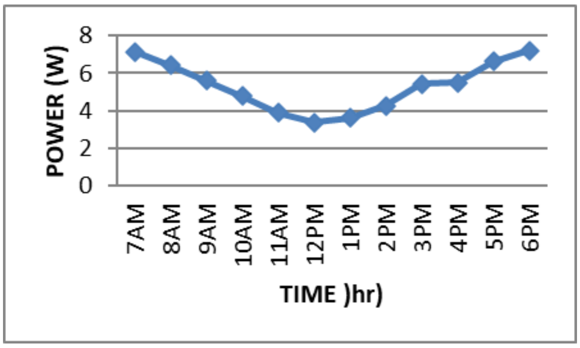

Figure 11 Output Power Wave form of Wind

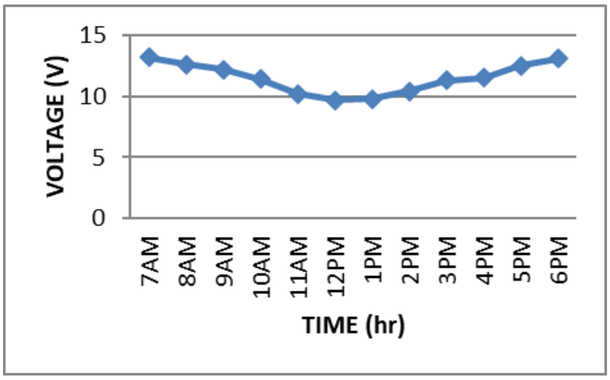

Figure 12 Output Voltage Wave form of Wind

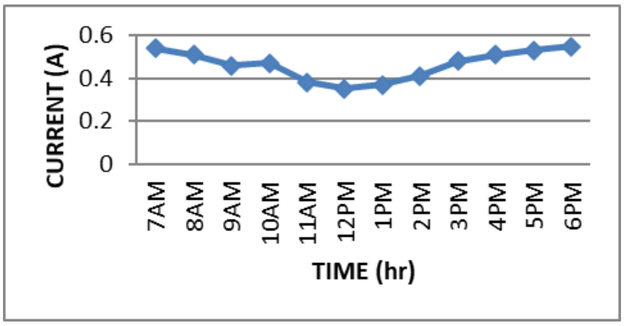

Figure 13 Output Current Wave form of Wind

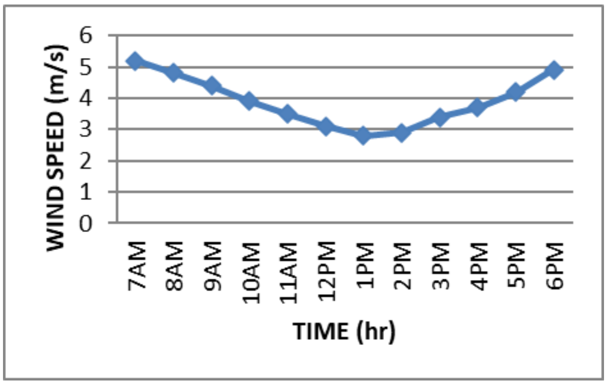

Figure 14 Output Speed Wave form of Wind

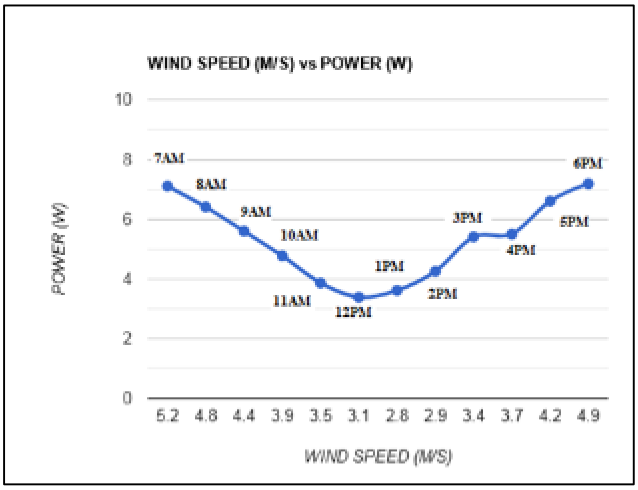

Figure 15 Output Power and Wind speed Wave form of Wind System

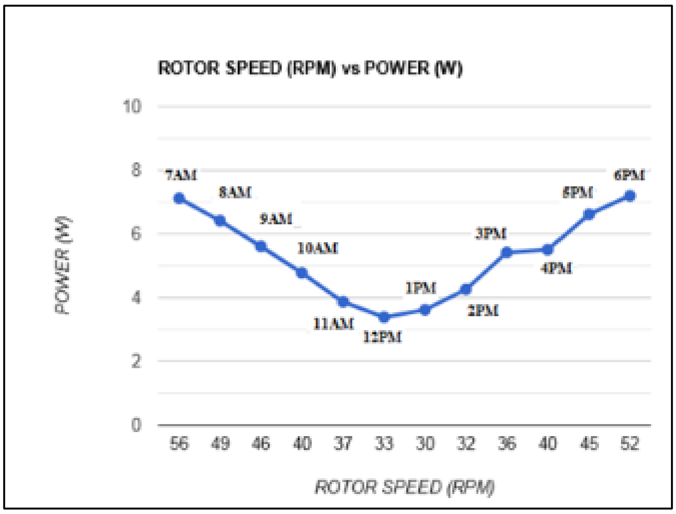

Figure 16 Output Power and Rotor speed Wave form of Wind System

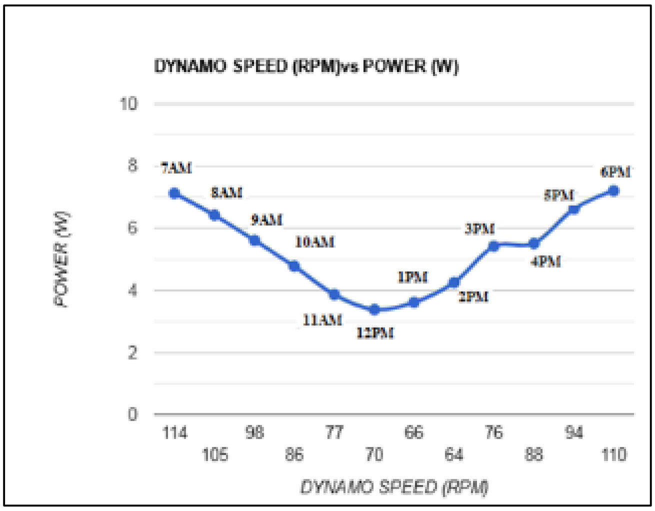

Figure 17 Output Power and Dynamo speed Wave form of Wind System

Table 5.3 shows the output result of voltage, current power and with respect of time for super lift LUO Converter system.

Table 4 Output Result for Super Lift LUO Converter

Time (hr)	Hybrid Input Voltage (V)	Hybrid Input Current (A)	Hybrid LUOConverter output Voltage (V)	Hybrid LUOConverter output current (A)	Output POWER (W)
7AM	22.8	0.66	32	0.7	22.4
8AM	23	0.67	31	0.6	18.6
9AM	24.4	0.68	32	0.8	25.6
10AM	24.1	0.75	32.5	0.7	22.75
11AM	23.4	0.7	32	0.72	23.04
12PM	23.5	0.71	32	0.7	22.4
1PM	24.1	0.79	31.5	0.8	25.2

2PM	24	0.99	32	0.9	28.8
3PM	24.1	0.85	32	0.8	25.6
4PM	23.9	0.8	31	0.84	26.04
5PM	23.7	0.78	32	0.8	25.6
6PM	23.6	0.74	30	0.7	21

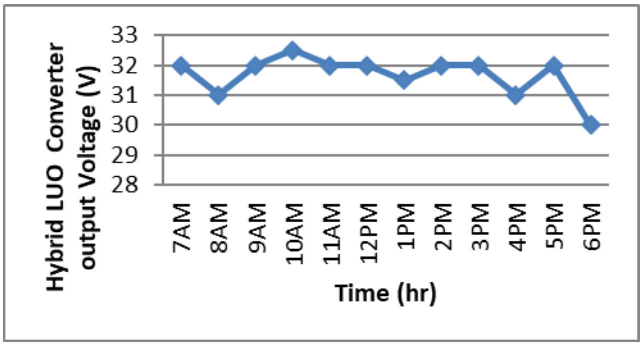

Figure 18 Output Voltage Wave form of Super Lift LUO Converter

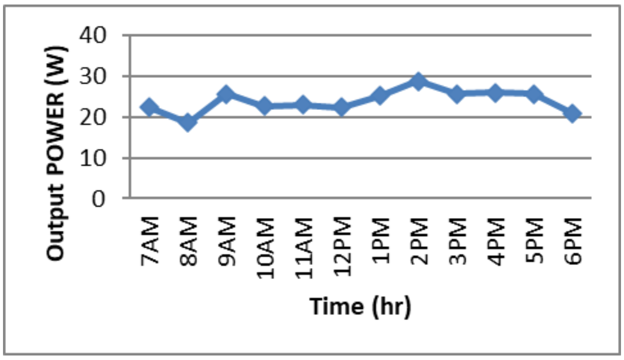

Figure 19 Output Power WaveformofSuper Lift LUO Converter

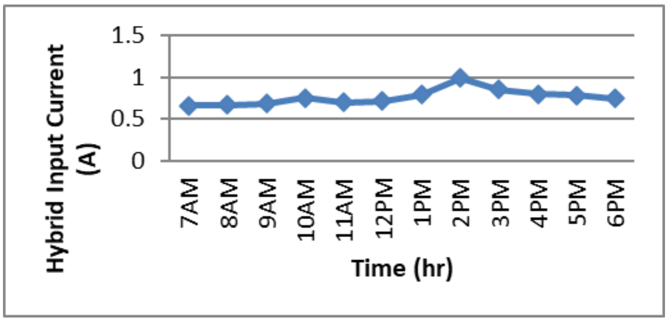

Figure 20 Input Current Wave form of Super Lift LUO Converter

5.1. Hardware output gain of the DSO

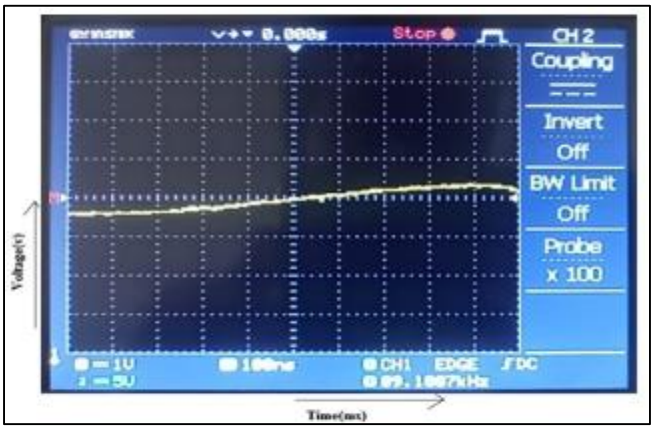

Figure 21 DC-DC converter output

Figure 5.17 displays the boost converter voltage, which is supplied by the battery and enhances the converter's output to over 24V DC.

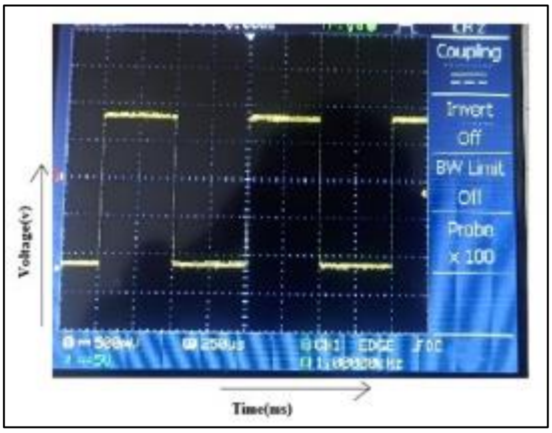

Figure 22 PWM Form the Microcontroller

Figure 5.18 illustrates the PWM voltage that is supplied to the inverter for converting the voltage fluctuations. The waveform clearly indicates that the PWM voltage is equal to 5VDC

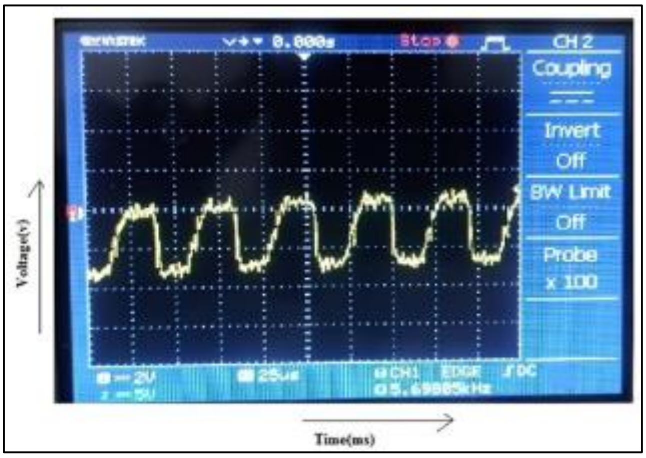

Figure 22 Inverter output

In Figure 5.19, the inverter gain for the hybrid method is shown, along with the power gain waveform when a load is connected. The voltage value is denoted as V=230V AC.

6. Conclusion

The present research shows the hardware prototype for a hybrid vertical axis wind turbine (savinous-type blades) that integrates a solar panel. With the help of this model, we developed a system that combines energy inputs from several sources and uses a battery for long-term and backup storage. The primary goal of the research is to provide a basic supply system for isolated, hilly areas and locations where the local population lacks access to an on-grid electrical supply. This can be useful in areas where "motor-roads" have not yet been built and the local population has a basic need for electricity, which can be met by minimum or small-scale energy generating.

To make provide a constant supply of power, the energy produced by the solar and wind power is subsequently stored in a battery unit and supplied to the load. For tracking maximum power, the MPPT Based Perturb and Observe (Hill Climbing Algorithm) controller is the most suitable alternative. The duty cycle of the super lift converter is the controller's output, and an inverter is connected to it to control the AC load. The hardware indicates that the proposed method to hybrid power generation is more efficient than alternative approaches.

This system can yet be optimized in terms of size if we need more supply in different applications. This is also possible for off-grid applications such as highway lighting, small homes and commercial centers with adequate off-grid electricity, etc.

References

[1] Sumit Wagh, Pratik Dhage, Amit Gavhad was Presented “A Review on Vertical Axis Wind Solar Hybrid Power System” ICSTM -18 ISBN: 978-93-86171-94-821stJan2018.

[2] Mohammed Mustafa, V. Sunil & Uday Bhaskar presented “Hybrid power generation by solar tracking and verticalaxis wind turbine” (design and analysis) International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04Issue: 08|Aug-2017.

[3] Raghunath L.,Senthilvel S.&P.Ilamathi presented “Hybrid Energy Generation Through Vertical Axis Savonius Wind Turbine and Solar Panel ”IJIRST–International Journal for Innovative Research in Science & Technology |Volume2 |Issue11|April2016 ISSN(online):2349-6010.

[4] P. Kala and S. Arora, “A comprehensive study of classical and hybrid multilevel inverter topologies for renewable energy applications,” Renewable Sustain. Energy Rev., vol. 76, pp. 905–931, 2017.

[5] Vikas Khare et.al, “Solar-wind hybrid renewable energy system: A review”, Renewable & Sustainable Energy Reviews 58 (2016).

[6] Yahia bouzelata, “Exploration of optimal design and performance of a hybrid wind-solar energy system”, International Journal of hydrogen energy 41(2016).

[7] Palash jain, “Performance prediction and fundamental understanding of small scale vertical axis wind turbine with variable amplitude blade pitching”, Renewable Energy97 (2016).

[8] CelikA.N.(2002) ‘Optimization and techno-economic analysis of autonomous photovoltaic –wind hybrid energy systems in comparison to single photovoltaic and wind systems’, Energy Conversion and Management,Vol.43,pp.2453-2468.

[9] R. A. Badwawi, M. Abusara, and T.Mallick, “A review of hybrid solar PV and wind energy system,” Smart Sci., vol. 3, no. 3, pp. 127–138, 2015.

[10] A. M. Eltamaly and A. A. Al-Shamma’a, “Optimal configuration for isolated hybrid renewable energy systems,” J. Renewable Sustain. Energy, vol. 8, no. 4, 2016, Art. no. 045502.

[11] M. H. Nehrir et al., “A review of hybrid renewable/alternative energy systems for electric power generation: Configurations, control, and applications,” IEEE Trans. Sustain. Energy, vol. 2, no. 4, pp. 392–403, Oct. 2011.

[12] K. Anoune,M. Bouya, A. Astito, and A. B. Abdellah, “Sizing methods and optimization techniques for PV-Wind based hybrid renewable energy system: A review,” Renewable Sustain. Energy Rev., vol. 93, pp. 652–673, 2018.

[13] B. R. Ravada, N. R. Tummuru, and B. N. L. Ande, “Photo voltaicwind and hybrid energy storage integrated multisource converter configuration-based grid-interactive microgrid,” IEEE Trans. Ind. Electron., vol. 68, no. 5, pp. 4004–4013, May 2021.

[14] L. Xu, X. Ruan, C. Mao, B. Zhang, and Y. Luo, “An improved optimal sizing method for wind-solar-battery hybrid power system,” IEEE Trans. Sustain. Energy, vol. 4, no. 3, pp. 774–785, Jul. 2013.

[15] Swarupa pinninti,I.V.V Vejitha,meka james Stephen “Design and modeling of vertical axiswind turbine and solar PV hybrid power generation system”, IJERT, vol 8, Issue 11, pp 441-447, 2019.

[16] Sunil Thomas, Mohammed ashar Riyan Khan , A B C chottapadhyay“Design and construction of a prototype vertical axis wind turbine (VAWT) for battery charging application” , IJET, vol 7, pp 621-625, 2019.

[17] Muhammad Munner, Shehan Ali, Khazar Hayat, “Design and development of a hybrid solar wind renewable energy generation system”, IEEE, 2019.

[18] B.N.Prashanth, R.Pramod, G.B.Veerein kumar, “Design and development of hybrid wind and solar energy system for power generation”, vol 5,pp 11415-11422, 2018.

[19] Ogunoh Chika, Ezemmuo Daniel, Ani Moses “Design and Construction of Vertical Axis Wind Turbine” Saudi Journal of Engineering and Technology ISSN 2415-6272 (Print) Scholars Middle East Publishers Volume 2, Issue 2, ISSN 2415-6264 (Online) Dubai, United Arab Emirates Website, Feb 2017

[20] P. Sai Chaitanya, SK. Slaman,V.Thulasi Ram Teja, K. Rakesh, SK. Audil Ahamed “Power Generation on Highway using Vertical Axis Wind Turbine” Dogo Rangsang Research Journal UGC Care Group I Journal Vol-08, Issue-14 No. 01, ISSN: 2347-7180 Pg no 421-426, 2021

[21] Chetan Sonawane, Manav Velani, Akash Singh and Vikaskumar Tripathi “Hybrid Power Generation System using Vertcal Axis Wind Turbine and Solar Panel” International journal of advanced research, ISSN:2320-5407, Pg no 167-173, April 2017

[22] Samir J.Deshmukh, Sagar M.Charthal “Design and Development Of Vertical Axis Wind Turbine” International Conference on Science & Engineering for Sustainable Development, ISSN 2455-4480 Pg. no.286-294, July (2017)

[23] J. Vignesh, A. Simon Christopher, T. Albert, C. Pravin Tamil Selvan, J. Sunil “Design and Fabrication of Vertical Axis Windmill with Solar System” Elsevier ISSN 2214-7853, Pg no:1-5, May 2019

[24] Parth Rathod, KapilKhatik, Ketul Shah, Het Desai, Jay Shah, “A Review on Combined Vertical Axis Wind Turbine”, International Journal of Innovative Research in Science, Engineering and Technology Vol. 5, Issue 4, ISSN(Online): 2319-8753, April 2016.

[25] Hafsa Murtaza, Soha Daudpota, Kubra Shah, Zaid Memona “Highway-Based, Vehicle Driven Vertical Axis Wind Turbine with Solar System”, International Journal of Electrical Engineering & Emerging Technology, Vol. 02, Issue No. 02, pp 18-21, Dec 2019

[26] S.Sivagami, k.Thamilarasan, Mohamath yousoof salamath shah, G.Saritha “Power Generation using Wind Turbine and Solar Energy”, European Journal of Molecular & Clinical Medicine ISSN 2515-8260 Volume 7, Issue 11, Pg no: 2295-2301, 2020

[27] Mr. Mohammed Mustafa, Mr. V. Sunil, Mr. Uday Bhasker “Hybridpower Generation by Solar Tracking and Vertical Axis Wind Turbine (Design and Analysis)”, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 08 | Aug -2017 www.irjet.net p-ISSN: 2395-00

[28] S.Gopalakrishnan , R. Sasikumar “Hybrid Power Generation using vertical Axis Wind Turbine and Solar Panel”, International Journal of Research in Engineering) and Science (IJRES) ISSN (Online): 2320-9364, ISSN (Print): 2320- 9356 www.ijres.org Volume 10 Issue 2,2022, PP. 37-45

[29] Vinit.V. Bidi, Devendrappa M. K, Chandan. S. P, Arun.J. P, Maruthi.G. V “Highway Power Generation using Low-Cost Vertical Axis Wind Turbine [VAWT]”, IJESC Volume 7 Issue No.5, PP. 12008-12012, (2017)

[30] M. Rambabu, JSS. Kalyan, T. Raja Vijaya Raju, CH. Sai Ram, V. Megha Shyam “Power Generation on Highway by Using Vertical Axis Wind Turbine with Solar System”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE) e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765 www.ijareeie.com Impact Factor: 7.122 Volume 9, Issue 6, Pg no: 1571-1578, June 2020.