SSRG International Journal of Electronics and Communication Engineering
ISSN: 2348-8549/ https://doi.org/10.14445/23488549/IJECE-V10I9P102

Volume 10 Issue 9, 10-19, September 2023

Original Article

Analysis of the High Efficient Renewable Energy Solar and Wind Powered Energy Systems and Its Applications

Parthasarathy K[1], Vijayaraj S[2]

[1,2]Department of Electrical and Electronics Engineering,
Vels Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, India.

[1]Corresponding Author : etechday@gmail.com

Received: 05 July 2023 Revised: 16 August 2023 Accepted: 05 September 2023 Published: 30 September 2023

Abstract *- Electricity is needed to charge those cars. The domestic supply can charge the vehicles at home using the AC charger. Charging facilities are available on interstate highways for automobiles while travelling long distances. These stations might receive their supply from renewable resources. The idea of a charging station that utilizes solar and wind renewable energies has been put out in this study. The single-diode model and analysis are employed. MATLAB-Simulink is used to obtain simulation results. Energy consumption and the requirement for power generation from Renewable Energy Sources (RES) are rising quickly. An Energy Storage System (ESS) is needed because these sources are sporadic. With the addition of Hybrid Renewable Energy Sources (HRES) such as Solar Photovoltaic systems (PV) and Wind Energy Conversion Systems (WECS) along with battery, this study achieves the widely utilized notion of renewable power generating technology. The Flyback converter and Fuzzy Logic Controller (FLC) boost the PV voltage generated to achieve stabilised voltage. In order to provide DC supply, the voltage from WECS is converted to DC using a Diode Bridge Rectifier (DBR). The battery converter receives the voltages derived from the HRES and electricity produced by various sources. With the help of the battery, the obtained DC voltage is used to operate an Electric Vehicle (EV) successfully. MATLAB Simulink examines the comprehensive structure, and the findings show that the suggested system is effective. The battery converter receives the voltages derived from the HRES and electricity produced by various sources. With the help of the battery, the obtained DC voltage is used to operate an Electric Vehicle (EV) successfully. MATLAB Simulink examines the comprehensive structure, and the findings show that the suggested system is effective.*

Keywords *- Energy consumption, Hybrid Renewable Energy Sources, Solar, Renewable energies, WECS.*

1. Introduction

The inverter, connected to multiple charging stations via bidirectional DC-DC converters, supplies the charge to the EV. The system onto the grid is arranged to equilibrium the load and consumption. No load is required because the battery is charged by supplying more influence from the grid. Power from wind turbines is produced using coupled bridge converters, and power from solar panels is produced using buck-boost converters.

To safeguard the circuit, the relay is attached to the battery. This technology offers a clean, healthy environment without pollutants and carbon emissions. The solar panels are arranged according to the need, as shown in the image. Electricity is produced by solar panels using light energy.

The atomic reaction occurs, and the electrons are drawn out of each solar cell when light strikes the solar panels. A larger quantity of voltage is produced from this array since more cells are connected in the module, and more modules are connected in the array. Depending on the need, the generated voltage is either directly used or stored [1].

Energy resources are undoubtedly the main engine of a nation's economy [2]. The enormous demand for energy worldwide is met by energy obtained from fossil fuels. However, because of its adverse environmental effects, conventional energy has recently lost popularity [3].

Although RES are only recently becoming more important in the electrical sector, they rapidly overtake conventional energy in many applications. It is clear from the shift to green energy that the energy sector is beginning a new evolution to achieve the objective of producing and consuming energy without emitting any emissions [4].

Due to the increased use of renewable energies, modern power generation has faced difficulties with system design, operations, and control [5]. Given the predicted high penetration levels of renewable energies, the demand to find novel controllers that can dampen system abnormalities has become a critical problem. Future power systems relying heavily on RES should be adequately designed, operated, and managed [6].

2. Literature Survey

As solar Photovoltaic (PV) power generation becomes increasingly widespread, its innate erratic nature makes developing and putting it into practice for smart networks difficult. Grid-tied solar power generation is a distributed resource due to the many deployed photovoltaic modules. Its outcomes could be unpredictable and provide the operator of the distribution system with many problems. As a result, battery energy storage is frequently used to help integrate solar electricity into the grid.

The suggested work effectively uses RES as the source of electricity generation by merging the Solar PV [7] system and WECS. Because wind [8] and PV energy are intermittent, different technologies and strategies have been used to make the power source more adaptable and compensate for load variations. As a result, the ESS is pre-installed to deal with problems with power imbalances and frequency variation and maintain system stability. The DC-DC converter is a significant part of power conditioning systems for renewable strength sources, including photovoltaic, wind, and energy compartment systems [9, 10].

Two categories serve as the main divisions for DC-DC converters. These two categories are impacted by a galvanic insulation's presence or absence [9]. As a result, there are two different groups of these converters: isolated converters and non-isolated converters [11]. Despite having a simple structural design, isolated converters struggle to reduce input current ripples due to input impedance caused by negative resistance as in the suggested task. Active PV voltage boosting is achieved by using Flyback converters [12].

A Proportional Integral (PI) controller is the converter operation that is most frequently used. It also has issues with poor responsiveness, increased overshoot, and oscillations in operational conditions. The operational Pl controller has been expanding sensibly since it has zero tracking error on sparse frequency. The controller, however, is confined when there is a continuous discharge while it is in operation [13].

Pl often works with fixed-value PI gains in industrial applications; they are inappropriate for non-linear systems. PID controllers, or Proportional Integral Derivative controllers, have dependability, symmetry, and quick reaction advantages.

Environmentally sustainable operation, PID controller use in networks is also severely constrained [14]. Artificial Neural Networks (ANN), a sophisticated soft computing method, have recently been proposed for adequate control. Although the ANN controller responds quickly to commands, the repercussions of this are poor accuracy [15]. The FLC technique exhibits a high response to control and is used in the proposed study for efficient Flyback converter regulation. This essay focuses on efficient HRES power generation. Utilizing a Flyback converter and FLC support, solar energy is increased. Similarly, DBR converts wind energy to DC [16]. Finally, a battery converter transfers voltage from various sources, which the electric vehicle battery uses.

3. Proposed System

HRES is gaining importance as a reliable, dependable energy source with low emissions and high flexibility, particularly for remote standalone power systems. HRES, which combines solar and wind energy, is successfully used as a source of power generation in the proposed work. The electricity generation for the method of active operation is outlined [17].

Flyback converter support that works with a primary power supply switch boosts the power produced by the PV system. It can also provide output from either a DC or an AC input. In order to stabilize the voltage, controllers are generally necessary [18].

The converter voltage achieves active stabilization when the FLC controller is used to supply the DC Link. Like WECS produces voltage, DBR converts WECS's voltage to DC, effectively converting AC voltage. The voltage collected from various sources is finally stored in the battery converter, supplying the EV battery for other applications. The efficiency of the suggested converter was 87.34%, with lower harmonics [19]. PT System Modeling in Section A PV cells are semiconductors that transform solar energy into electrical electricity.

Solar panels and primary winding energy are connected to the primary side of the transformer when the switch is switched ON. Due to the polarities of the primary and secondary windings, series diodes on the secondary side get critically biased and stop conducting; the voltage of the PV and the diode is provided by the expression above as V and Vsch output voltage as V0. The transformer turn ratio is represented by the numbers n and t, respectively.

3.1. Fuzzy Logic Controller (FLC)

Fuzzy logic control systems are built on a mathematical foundation that evaluates analogue input values. Unlike classical or digital logic, which operates on discrete input or output data, fuzzy logic variables express continuous values for both input and output [20]. The FLC technique's Strong converter stability, good dynamic response, and simplicity of implementation are all features of this control approach.

3.2. Fuzzy Rules

Finally, the DC connection successfully receives the controller voltage from the PV source for further processing. Similar to this, another source of power generation in the planned work is wind. The creation of WECS is covered in the following section [21]. The wind turbine accelerates the DFIG at various speeds by capturing some of the wind's kinetic energy. PMAX=PRV C is the formula for extremely powerful [22]. Air density is given as p, turbine radius as R, wind speed as V, power coefficient as Cp, blade orientation as and velocity ratio from the above-described expression.

4. Result and Discussion

MATLAB is used to validate the overall experimental design, and the results show how successful the suggested framework is. The Figure 1 parameter specification values for the PV system, WECS, and Flyback converter are listed as values PV module Voltage Open Circuit (VOC) 22.54 V (c) Short circuit current 5.28A, Peak (Pimp) power system 12 Panels 1000W, voltage at output 48V, RMS power backward converter 1000W, Capacitor 100μf, Inductor 0.6mH. The obtained PV voltage coupled with the converter input waveform. It has been noted that the PV system consistently produces 120V. The converter voltage obtained is increased and kept stable with 120V per the PV voltage [22].

The waveform represents voltages derived from several sources. It is noted that sources 1, 2, and 3 produce a steady voltage of 60V with slight distortion. The voltage acquired from source 4 fluctuates initially before stabilizing after 0.06 seconds with a higher voltage of 120K than the other sources. The waveform illustrates the battery's state of charge. It is noted that a consistent and continuous battery voltage of 60V is attained.

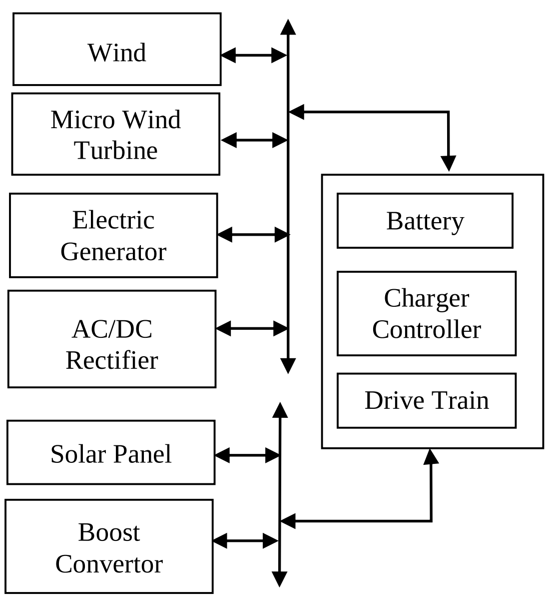

Fig. 1 Block diagram

Since a battery provides the energy needed to power an electric automobile, it is essential in these vehicles. A solitary power source charges the battery. In contrast, the battery in a hybrid electric vehicle is charged using various sources, as in this work [23].

5. Suggestive System

The surplus energy in the battery is utilized when the PV panels cannot absorb enough energy. A deep discharge of the battery is avoided. The proper operation of multiple sources of charging requires the MPPT. Using a timer, the power supply is turned ON and OFF for the controllers. As a result, charging can take longer. This paper discusses the creation of a hybrid charge controller for batteries. The battery model is constructed to support the characteristics of both recharging and charging. Maximum voltage, current, and efficiency are the parameters. The battery is created by shortening the charging process. When it is warm out, solar energy is utilized. In colder weather, power is strained from the grid. This work uses the simulation of electric vehicles and the energy system [24].

The sun and wind renewable energy system is depicted in the above figure. The grouping of solar and wind energies is done to increase the use of EVs and reduce the power demand. Fossil fuel use can be reduced while the environment is safeguarded by using renewable resources [25]. Solar energy is prevalent and well-liked, but power stability is challenging. However, merging with another energy source makes it possible to accomplish it.

6. PV Pipe

PV systems are frequently used for household or business purposes. They can be positioned on the building's top or ground level [26-33]. The block plan of the model is displayed in the above figure. The power source is recharged throughout the day using wind and solar power.

Due to the wind's activity at night, the power pack is partially charged. Battery backups are used to charge automobiles for power when electricity is needed. If the car needs a DC charge, the converter charges it [34]. If the car requires AC power, the battery is linked to the inverter, which is then charged. Depending on the situation, buck or boost controls are used to manage the power yield from the solar panel. The storage battery will receive a modest charge daily and at night.

The load demand is balanced because it has additional charging ports, and excess energy is produced [35]. There are several problems where a considerable quantity of harmonic energy is unavoidable, and the performance of a PV system is dependent on temperature, which may change the current and voltage profile. However, the THD at various testing locations decreases as EVs increase. Harmonics can be avoided by placing the charging station near the renewable resource. Installing the appropriate filter in such a spot is one of the defence mechanisms. Transformers cause harmonics, so installing an EV charging station should be done away from them.

7. The Machining of a Wind-Solar Tree

The Figure 2 constructed wind-solar tree is displayed. It has three branches on which three wind turbines can be mounted at an angle of 1200 to one another. Each wind turbine's top and the tree's steam have solar panels [36]. A tree is built on top of a strong concrete foundation using the fasteners. The tree measures 8 feet in diameter and 12 feet in height. The Figure 3 batteries will receive additional power generated by each wind turbine. The power produced at each turbine in the current work must be transformed from three-phase AC to Direct Current (DC) for battery charging.

As a result, a bridge rectifier made of diodes converts three Phase AC power initially into DC. The battery is then charged using a buck converter, which maintains a constant maximum voltage.

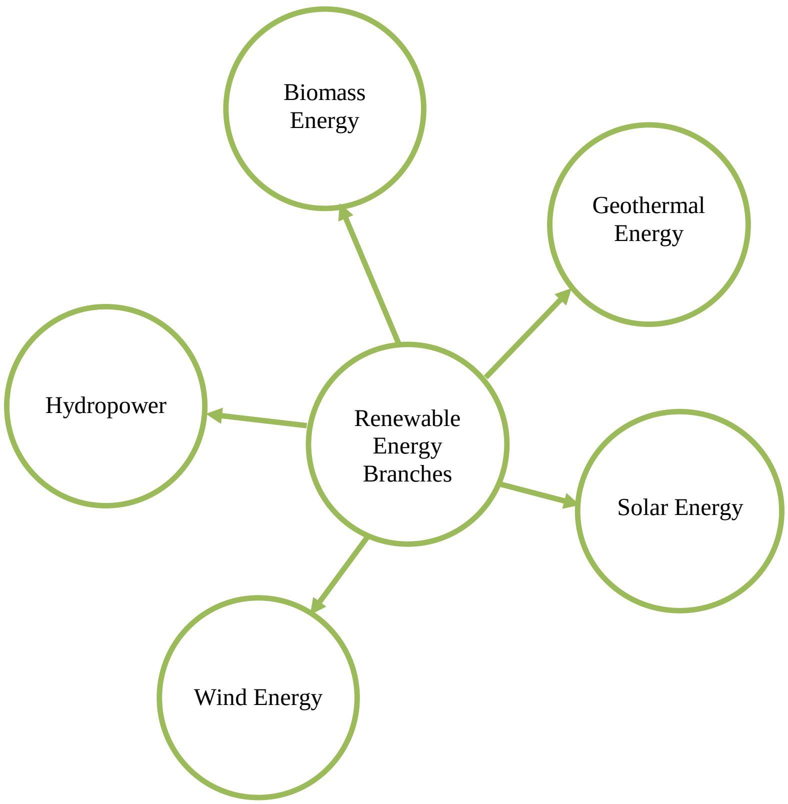

Fig. 2 Renewable energy branches

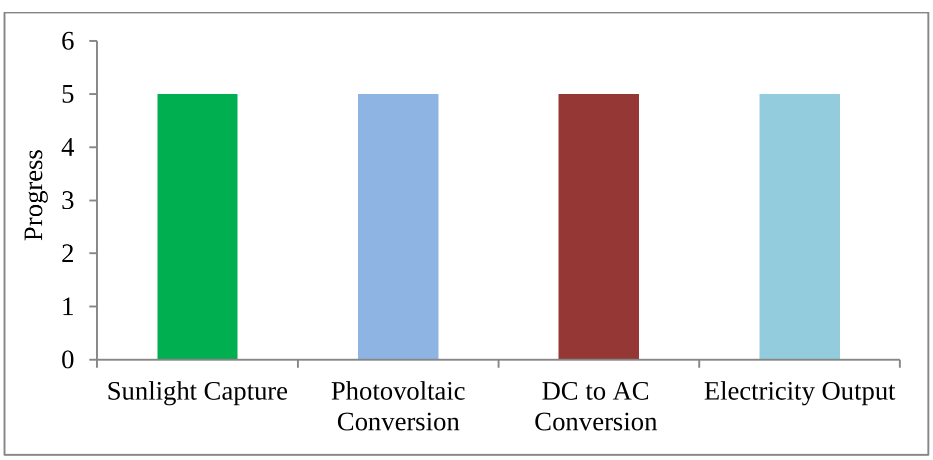

Fig. 3 High-efficiency renewable energy system

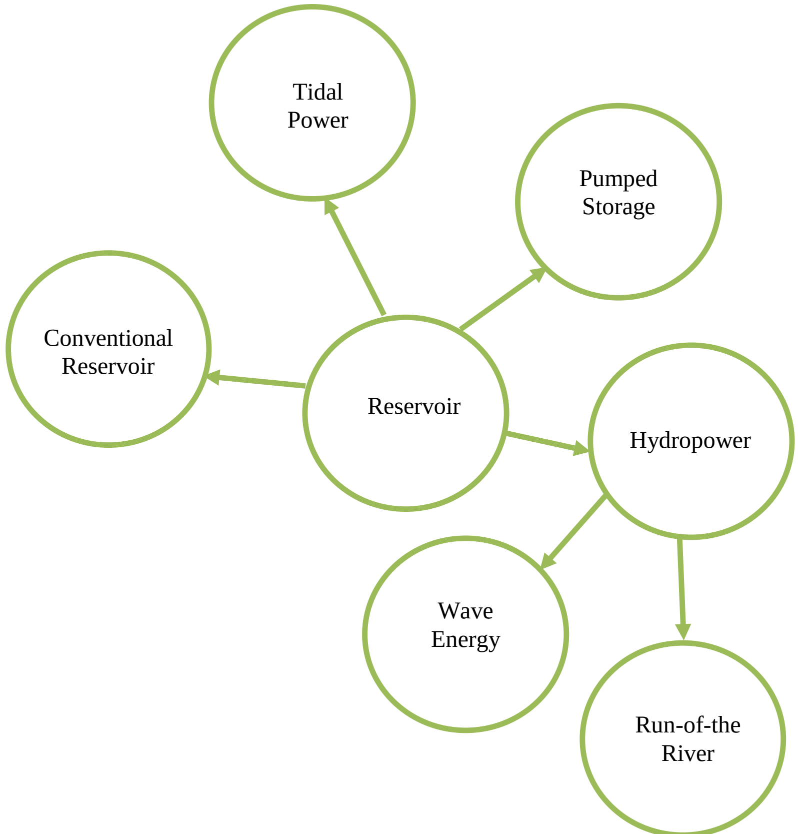

Fig. 4 Hydropower branches

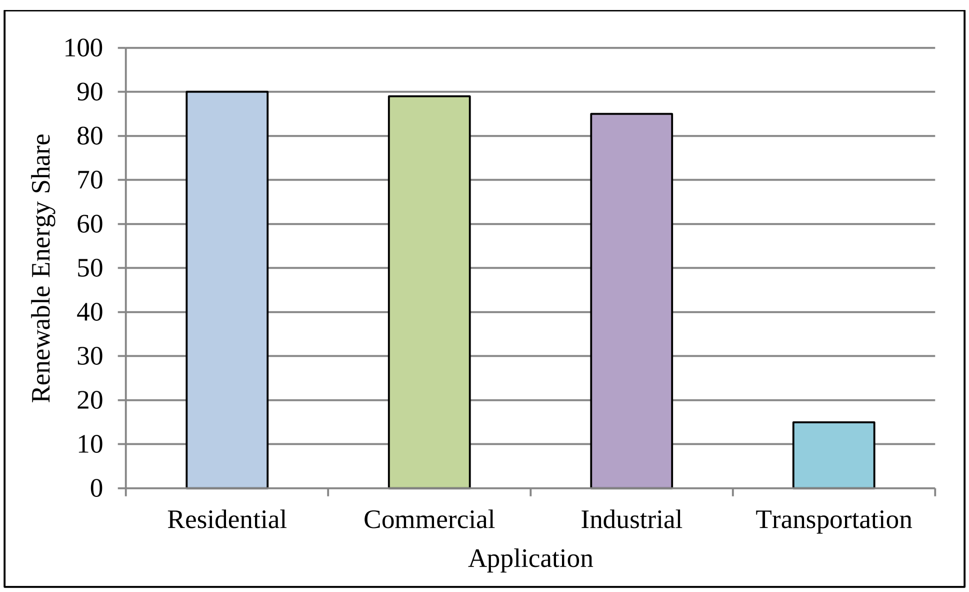

Fig. 5 Renewable solar applications

8. Future Scope

The Figure 4 hybrid wind-solar system is the most excellent way to capture renewable energy throughout the day and night. The most effective design is one that resembles a tree structure. Four 40W solar panels are employed in the current work to generate about 160W of power from solar energy. Additionally, a tree structure is used to install the three vertical axis savonius turbines, which have a combined 300W capacity. Artificial intelligence manages energy in the [37-39] system, which utilizes different energy sources. The investigation includes a presentation of the energy management coordination structure. The limitations of centralized techniques are eliminated by using artificial neural networks [40]. According to Figure 5, as more applications are created and more research is done in this field, the potential for AI technologies in microgrids is growing.

9. Applications of Artificial Intelligence in Microgrids

Figures 6 and 7 control all of the scattered energy sources in a microgrid effectively, and it is essential for efficient system usage. In Figure 8, artificial intelligence technologies benefit microgrid organizations in numerous ways. Numerous applications of artificial intelligence have been discovered and are still being developed. Prediction, optimization, control, and monitoring are just a few of the operations-related applications of AI technology. It sounds like you are looking to create a graph that represents the output of a solar energy system with a capacity of 10 Mega Watts (MW). However, solar energy output can vary based on location, weather conditions, and time of day. Without specific data, I can provide a general formula for calculating solar energy output and an example graph based on assumed data. Remember that this example is illustrative and may not accurately reflect real-world conditions.

10. The formula for Solar Energy Output Calculation

Figure 9 solar energy output can be calculated using the following formula:

$$\text{Energy output (kWh)} = \text{Solar capacity (kW)} \times \text{Solar radiation (kWh/kW/day)}$$

Assuming an average solar radiation of 5 kWh/kW/day, the formula simplifies to:

$$\text{Energy output (kWh)} = \text{Solar capacity (kW)} \times 5 \text{ (kWh/kW/day)}$$

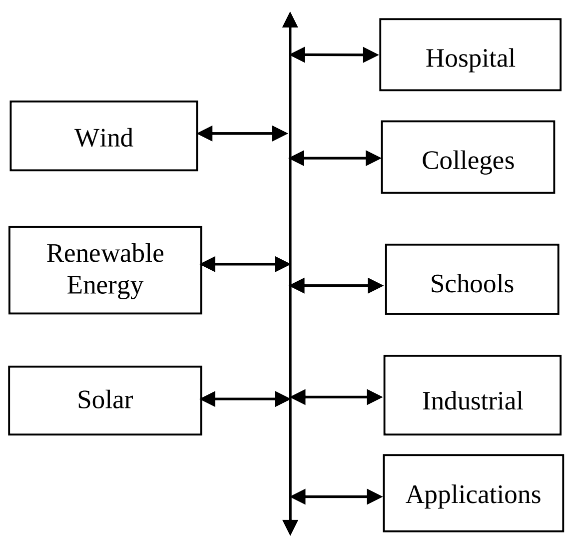

Fig. 6 Block diagram of applications

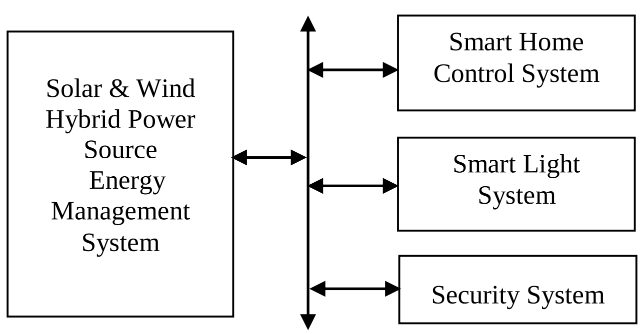

Fig. 7 Applications of energy management system

The Significant impact of one unit of power saved and the importance of non-renewable energy in streetlight energy conservation. The efficiency of Photovoltaic (PV) cells is increased, and low-grade heat is produced by integrating a PV and thermal system into one system. Only a few efficient PVT systems are currently offered to consumers, although researchers have been trying to improve the PVT system for the past two to three decades.

To optimize the performance of PV solar panels, this study analyzes several tracking and cooling strategies used to detect maximum sun radiations and reduce the likelihood of rising temperatures. As a result, many research papers have been evaluated and categorized according to their focus, significance, and the technologies employed for PV panel tracking and cooling. New researchers interested in working in this field and technology would benefit from this research.

Suppose you want to plot a 10 MW solar system's daily energy output over a week. We will use the simplified formula above and assume the solar capacity remains constant.

Day	Solar Energy Output (kWh)
1	10,000 kW×5kWh/kW/day=50,000 kWh

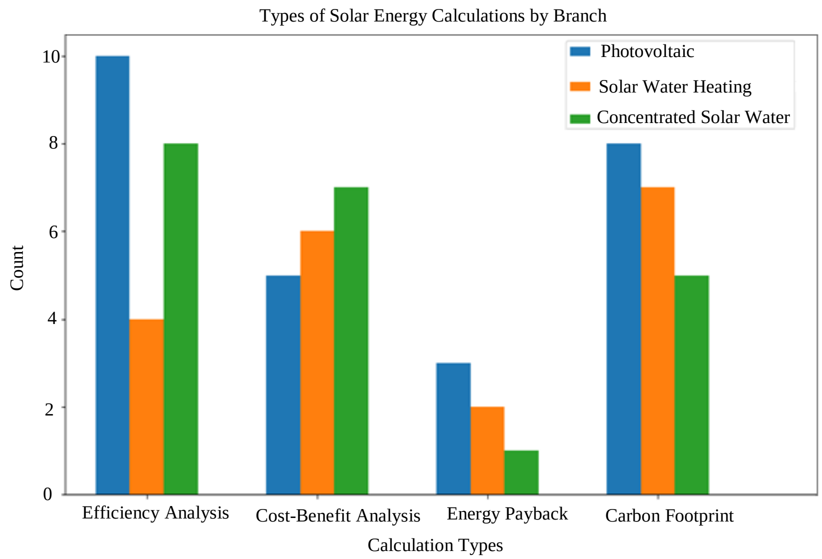

Fig. 8 Output solar energy efficiency

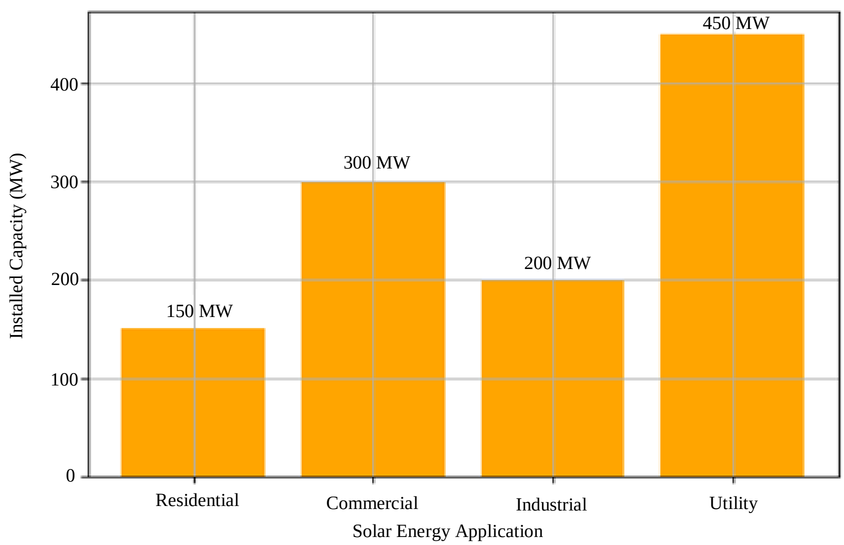

Fig. 9 Output solar energy applications

11. Conclusion

In order to select the most effective HRES while considering the distinct economic and environmental implications of each technology, the expanding use of renewable energy is essential, within the suggested work. Utilizing an HRES system with solar and wind energy, in the proposed work, the voltage produced by PV is increased with the help of a Flyback converter and FLC for active stabilization. The HRES-obtained voltage is delivered to the battery converter through an EV battery for further use. The Flyback converter's use achieves an efficiency of 87.34%, actively contributing to the system. Additionally, the designed technology results in uninterrupted power delivery and offers more excellent dependability.

References

[1] Grazia Barchi et al., "Residential Renewable Energy Community: A Techno-Economic Analysis of the Italian Approach," *2023 IEEE International Conference on Environment and Electrical Engineering and 2023 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)*, Madrid, Spain, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[2] Omorogiuwa Eseosa, and Adesaanu Eunice Ejiroro, "Challenges and Way Forward of Renewables in Developing Energy Economy: Today and Tomorrow," *International Journal of Recent Engineering Science*, vol. 7, no. 4, pp. 14-19, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[3] Mohammad Afkar et al., "Losses Calculation of a Two-Input Boost Converter for Renewable Energy Applications," *2023 8th International Conference on Technology and Energy Management (ICTEM)*, Mazandaran, Babol, Iran, pp. 1-5, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[4] Atif M. Mohammad et al., "Optimal Economic Dispatch of Power System Networks with Renewable Energy Sources," *2023 IEEE PES Conference on Innovative Smart Grid Technologies - Middle East (ISGT Middle East)*, Abu Dhabi, United Arab Emirates, pp. 1-7, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[5] Thiagarajan Kittappa et al., "Artificial Intelligence Based Electronics Engineering Software Application System," *2023 5th International Conference on Smart Systems and Inventive Technology (ICSSIT)*, Tirunelveli, India, pp. 1170-1173, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[6] Monika Khatri et al., "Integrating Solar Energy with Battery Storage Systems for Optimal Efficiency Using Landsman Converter," *SSRG International Journal of Electrical and Electronics Engineering*, vol. 10, no. 8, pp. 89-101, 2023. [CrossRef] [Publisher Link]

[7] Suchismita Patel, Arnab Ghosh, and Pravat Kumar Ray, "Fuzzy Logic Control Based Energy Management in Hybrid Microgrid System," *2023 5th International Conference on Energy, Power and Environment: Towards Flexible Green Energy Technologies (ICEPE)*, Shillong, India, pp. 1-5, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[8] Sontyana Thanuja Lakshmi Sravanthi, Lahari A., and D.V. Siva Krishna Rao K., "State of Health Estimation of an Electric Vehicle Battery Using Fusion Technology," *2023 5th International Conference on Energy, Power and Environment: Towards Flexible Green Energy Technologies (ICEPE)*, Shillong, India, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[9] Jianfeng Fu, and Yu Gong, "Hybrid Vessels Scheduling Strategy for Energy Transportation among Pelagic Isles," *2023 6th International Conference on Energy, Electrical and Power Engineering (CEEPE)*, Guangzhou, China, pp. 1365-1370, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[10] P. Deepa et al., "New Hybrid Cuk-Landsman High Gain DC-DC Converter Modelling and Analysis," *SSRG International Journal of Electrical and Electronics Engineering*, vol. 9, no. 8, pp. 8-16, 2022. [CrossRef] [Publisher Link]

[11] Shizhe Xiang, Da Xu, and Menglu Gao, "Optimal Portfolio of Wind-Solar-Hydro Hybrid Renewable Generation Based on Variable Speed Pumped Storage," *2023 IEEE 6th International Electrical and Energy Conference (CIEEC)*, Hefei, China, pp. 2371-2376, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[12] Karanam Deepak et al., "Novel Control of Standalone Hybrid Wind-PV-Battery System for Improving Power Quality," *2023 Second International Conference on Electronics and Renewable Systems (ICEARS)*, Tuticorin, India, pp. 422-427, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[13] Cheng Long et al., "Wavelet-Based Hybrid Energy Storage System for Smoothing Electric Tractor Power Fluctuations," *2023 International Conference on Future Energy Solutions (FES)*, Vaasa, Finland, pp. 1-4, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[14] Bhavya Pandya, and Siddharth Joshi, "Simulation and Analysis for 100kW Standalone Hybrid Renewable Energy System," *2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT)*, Male, Maldives, pp. 1-7, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[15] B. Uytterhaegen et al., "Dimensioning Lithium-ion Battery Packs and Fuel Cells for Hybrid Power Systems," *2023 IEEE Conference on Power Electronics and Renewable Energy (CPERE)*, Luxor, Egypt, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[16] D. Lingaraja et al., "Design of Solar Energy Harvester for Smart Home Application," *2023 5th International Conference on Smart Systems and Inventive Technology (ICSSIT)*, Tirunelveli, India, pp. 1-5, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[17] Saranya Athipatla et al., "Solar Powered Bluetooth Controlled Grass Cutting Robot," *2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS)*, Coimbatore, India, pp. 1-7, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[18] M. Jyotshna et al., "Implementation of Solar Based Multipurpose Agriculture Robot Using Random Forest Algorithm," *2023 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computational Intelligence (RAEEUCCI)*, Chennai, India, pp. 1-5, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[19] Carla P. Gomes, "Keynote: AI for Scientific Discovery and a Sustainable Future," *2023 IEEE International Conference on Pervasive Computing and Communications (PerCom)*, Atlanta, GA, USA, pp. 1-1, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[20] T. Sana Amreen, Radharani Panigrahi, and N.R. Patne, "Solar Power Forecasting Using Hybrid Model," *2023 5th International Conference on Energy, Power and Environment: Towards Flexible Green Energy Technologies (ICEPE)*, Shillong, India, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[21] Sarun Chattunyakit et al., "Estimation of Solar Power Generation Using Ensemble Learning and Algebraic Combiners," *2023 International Electrical Engineering Congress (iEECON)*, Krabi, Thailand, pp. 351-354, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[22] Bhavana Dantu et al., "Implementation of Perovskite Solar Cells Using GPVDM," *2023 3rd International Conference on Artificial Intelligence and Signal Processing (AISP)*, Vijayawada, India, pp. 1-3, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[23] Xianwu Liang, and Dongqing Hou, "Solar Investment Decision Application System Based on Big Data Technology," *2023 IEEE 3rd International Conference on Information Technology, Big Data and Artificial Intelligence (ICIBA)*, Chongqing, China, pp. 764-768, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[24] Salah Alhashedi et al., "Multi-Period Optimization of Hybrid Energy Systems Using Mixed Integer Linear Programming," *2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT)*, Male, Maldives, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[25] Mulugeta Tadesse, "The Developmental Patterns of Injera Baking Stoves: Review on the Efficiency and Energy Consumption in Ethiopia," *SSRG International Journal of Mechanical Engineering*, vol. 7, no. 1, pp. 7-16, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[26] Pouya Ramezanzadeh, Hamed Delkhosh, and Mohsen Parsa Moghaddam, "Forecasting the PV Panel Power Based on Image Processing and Historical Outputs," *2023 10th Iranian Conference on Renewable Energy & Distributed Generation (ICREDG)*, Shahrood, Iran, pp. 1-5, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[27] Haoran Lu et al., "Defect Detection of Photovoltaic Panels Based on Deep Learning," *2023 3rd International Conference on Neural Networks, Information and Communication Engineering (NNICE)*, Guangzhou, China, pp. 99-103, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[28] Muneeb Wali, and Ashish Sharma, "An Online Fault Detection and Classification Monitoring Scheme for Photovoltaic Plants," *2023 Second International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT)*, Tiruchirappalli, India, pp. 1-7, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[29] Mahmoud Meribout, "Sensor Systems for Solar Plant Monitoring," *IEEE Transactions on Instrumentation and Measurement*, vol. 72, pp. 1-16, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[30] Mohammad Khenar et al., "Intelligent Control of an Islanded Hybrid Microgrid," *2023 IEEE International Conference on Industrial Technology (ICIT)*, Orlando, FL, USA, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[31] Girish Kalele et al., "Improved Algorithm for Solar Power Systems for Efficient Tracking System," *2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)*, Greater Noida, India, pp. 2595-2598, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[32] S. Priya et al., "An Efficient Monitoring Scheme for Standalone Solar PV System Using IoT," *2023 8th International Conference on Communication and Electronics Systems (ICCES)*, Coimbatore, India, pp. 391-395, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[33] M. Karthika et al., "Solar Fed Flood Alert System Using Arduino," *2023 IEEE 3rd International Conference on Technology, Engineering, Management for Societal Impact Using Marketing, Entrepreneurship and Talent (TEMSMET)*, Mysuru, India, pp. 1-7, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[34] Sumathi R., "Design and Implementation of Solar Based Day and Night Battery Charger," *2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS)*, Coimbatore, India, pp. 54-57, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[35] Aryadip Sen, and Bhim Singh, "SVSC Controlled Motion Sensor Free Solar Powered BLDCM Drive," *2023 IEEE International Conference on Environment and Electrical Engineering and 2023 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)*, Madrid, Spain, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[36] M. Karthik et al., "Arduino Based Dual Axis Smart Solar Tracking System," *2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS)*, Coimbatore, India, pp. 169-174, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[37] Josef Miller, Mauro Garcia, and Baris Aksanli, "WIP: Optimizing Solar-Powered BLE Beacons for Wildlife Monitoring," *2023 IEEE 24th International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM)*, Boston, MA, USA, pp. 312-315, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[38] Sifatuzzaman Niloy et al., "Solar Powered Smart Irrigation System Based on Internet of Things (IoT) Using Microcontroller," *2023 3rd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)*, Dhaka, Bangladesh, pp. 259-263, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[39] Varsha Mittal et al., "Intelligent Street Lighting System Using LoRa Network and Piezoelectric Sensors," *2023 7th International Conference on Trends in Electronics and Informatics (ICOEI)*, Tirunelveli, India, pp. 77-81, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[40] Manali Fulzele, and Shradha Umathe, "PV System with Energy Monitoring to Enhance System Reliability," *2023 International Conference for Advancement in Technology (ICONAT)*, Goa, India, pp. 1-6, 2023. [CrossRef] [Google Scholar] [Publisher Link]