# A NEW ENERGY STORAGE SYSTEM CONFIGURATION TO EXTEND LI-ION BATTERY LIFETIME FOR A HOUSEHOLD

[1]DR.CHANDRASHEKHAR REDDY.S, [2]NIKHITHA

[1]Professor in EEE, Christu Jyothi Institute of Technology & Science, Jangaon, Telangana, India.

[2]PG Student, Christu Jyothi Institute of Technology & Science, Jangaon, Telangana, India.

## ABSTRACT

A new home energy storage system (HESS) configuration using lithium-ion batteries is proposed in this article. The proposed configuration improves the lifetime of the energy storage devices. The batteries in this system can be charged by either using solar panels when solar energy is available or by using the grid power when the electricity cost is at its lowest rate during off-peak hours. In the proposed configuration, the battery bank is split into two sections, and the pulsed charge–discharge method is employed. This method helps to prolong the life of the lithium-ion batteries while maximizing the solar energy utilization that leads to reduce the consumer's total energy cost. In order to demonstrate the benefits of the proposed method, different modes of operation are discussed in detail along with the simulation results. A prototype was developed to demonstrate the performance of the proposed system experimentally.

***Keywords: HESS, BESS, TOU, EOL, DOD, ICT, DR, RES.***

## I INTRODUCTION

Recently, many vendors have shown more interest in energy storage systems using rooftop solar panels for household applications to reduce the dependency to the grid power. An energy storage system can be built without or with a green energy source. A home energy storage system (HESS) without a green energy source utilizes electrical power from the grid to charge its battery bank and use the stored energy when it is required. Uninterrupted power supply (UPS) is an example of such a system when the battery bank provides power to the critical loads during a power outage. They can also be used to reduce the energy cost in the areas that the electricity cost is variable. The energy storage system without green energy source charges the battery bank when the electricity price is low and discharges the battery bank when the electricity price is high. [1] [2] The disadvantage of an energy storage system without renewable energy source is the increase in the net produced $CO_2$ , $SO_2$ , and NOx emissions due to storage system inefficiencies. Therefore, home energy storage does not reduce the emissions and energy consumption unless a renewable energy source such as solar or wind energy is integrated in the system. [2] [3] Energy Storage systems allow self-consumption of electricity generated for household applications using photovoltaic solar panels. This helps to reduce the extra stress on the local grid equipment during peak hours. [4] [5] Also, it helps to reduce the energy cost either by storing low-cost energy during off-peak hours or free solar energy at any time of the day. [5] [6] A number of charge and discharge scenarios can be used to enhance the utilization of an energy storage systems based on the time of use (TOU) which it varies by jurisdiction.

In recent years, many electrical utilities have started converting regular meters to smart meters for residential areas. Basically, the smart meters record the consumed electric energy and the time of measurement continuously. They send this information to a central system for billing based on TOU. Due to electricity cost difference between off-peak hours and on-peak hours, an energy storage system can be used to charge the battery bank during off-peak hours when the electricity cost has the lowest rate. During on-peak hours, when the electricity cost is at its highest rate, the discharging cycle is enabled. This method helps reduce the grid energy cost. Clearly, employing an energy storage system will be more feasible and beneficial if the energy cost difference between on-peak and off-peak hour's increases. [7] [8] [9].

Generally, unmanned injection of electrical power into the grid boosts the grid voltage locally and can cause damage to the equipment if the injected power is significantly high, That is why electrical utilities do not allow consumers to inject power to the grid without having a permit. Hence, in this thesis, it is considered that the household consumer is not injecting any electrical power to the grid. In order to overcome this restriction, the HESS controller monitors the incoming power from the grid and the consumed power on the household loads continuously. Using these readings, HESS controls the Grid-Tie inverter output power to prevent injecting electricity to grid at any time. Most of the energy storage systems use electronically batteries as their energy reservoirs. For household applications, Battery energy storage systems still need to overcome some barriers to be able to integrate into the power systems. High battery cost, lack of financial compensation, and safety are some of these barriers. [10] The battery storage system should be capable for supplying long charge or discharge cycles. So that, Deep-Cycle batteries would be good candidates for such a system. Also it should have the capability for high number of charge-discharge cycles. In other words, the life time of the batteries should be long enough as the battery bank is generally the most expensive component of an energy storage system. Hence, the longer battery life time or the higher end of life (EOL) renders the more feasible system. For these reasons, Lithium-ion battery would be a good choice due to its advantages versus the lead acid batteries. [11] [12] The existing home energy storage systems generally utilize a single battery bank. Although, they can improve the life time of the batteries by reducing the charge or discharge current or the depth of discharge (DOD), this is affects the charging time and performance of the overall system. In this thesis, a new strategy to employ the battery bank is suggested to extend the battery lifetime while maximizing the utilization of the renewable energy system.

## II LITERATURE SURVEY

D. E. Olivares et al., "Trends in Microgrid Control," in IEEE Transactions on Smart Grid, vol. 5, no. 4, pp. 1905-1919, July 2014, doi: 10.1109/TSG.2013.2295514. The increasing interest in integrating intermittent renewable energy sources into microgrids presents major challenges from the viewpoints of reliable operation and control. In this paper, the major issues and challenges in microgrid control are discussed, and a review of state-of-the-art control strategies and trends is presented; a general overview of the main control principles (e.g., droop control, model predictive control, multi-agent systems) is also included. The paper classifies microgrid control strategies into three levels: primary, secondary, and tertiary, where primary and secondary levels are associated with the operation of the microgrid itself, and tertiary level pertains to the coordinated operation of the microgrid and the host grid. Each control level is discussed in detail in view of the relevant existing technical literature.

The impacts of storing solar energy in the home to reduce reliance on the utility There has been growing interest in using energy storage to capture solar energy for later use in the home to reduce reliance on the traditional utility. However, few studies have critically assessed the trade-offs associated with storing solar energy rather than sending it to the utility grid, as is typically done today. Here we show that a typical battery system could reduce peak power demand by 8–32% and reduce peak power injections by 5–42%, depending on how it operates. However, storage inefficiencies increase annual energy consumption by 324–591 kWh per household on average. Furthermore, storage operation indirectly increases emissions by 153–303 kg $CO_2$, 0.03–0.20 kg $SO_2$ and 0.04–0.26 kg $NO_x$ per Texas household annually. Thus, home energy storage would not automatically reduce emissions or energy consumption unless it directly enables renewable energy.

D. Keles, T. Telsnig, B. Fleischer, M. Baumann, D. Fraboulet, A. Faure, W. Fichtner. (2015). Self-consumption of Electricity From Renewable Sources. INSIGHT_E, If the cost of energy production from renewable energy sources (RES) reduces below the level of electricity retail prices, self-consumption (SC) can contribute to market integration of RES. Support schemes such as feed-in tariffs could be phased out in view of parity of retail prices and RES production costs. In combination with electricity storage and demand response (DR), SC can facilitate the integration of variable renewables onto the grid and lower the overall costs of the energy system through load shifting particularly if storage and DR is managed using ICT and algorithms controlling charging cycles and usage of electric devices. Some issues remain however: Self-consumption potential is limited without further technical enhancements in storage or DR solutions. To organize self-consumption efficiently, measures on the grid side and energy storage have to be taken. Enabling the grid to provide necessary information back to prosumers and vice versa, as well as developing economic ways of storing energy is key to unleashing the potential that lies within the transition from passive consumers to active prosumers.

S. V. Kuchak, A. N. Voroshilov and E. A. Chudinov, "Discharge characteristics of lithium-ion accumulators under different currents," The paper deals with time diagrams of voltage and discharge characteristics of lithium-ion accumulators with LiFePO 4 cathode material, obtained under the different discharge rates. Based on obtained results the internal resistance value estimations is provided. The result will be useful for design of energy storage systems.

L. Wu et al., "Development of a solar-power-based nanogrid system for village huts in Haiti mountain area, Most people living in the mountain areas of Haiti suffer from lack of electricity. In this paper, a nanogrid system based on solar power is designed to im prove their living conditions by enabling lighting and cell phone charging inside their residential huts. The nanogrid system consists of a controller board that routes power from the solar panel to separate loads through USB ports. Simulation and experimental validation of the system have been demonstrated and the authors have implemented the designed system in two huts in Haiti with satisfactory performance. The project helps with addressing the daily needs of people and provides an example of constructing nanogrid systems in areas with no access to the power grid.

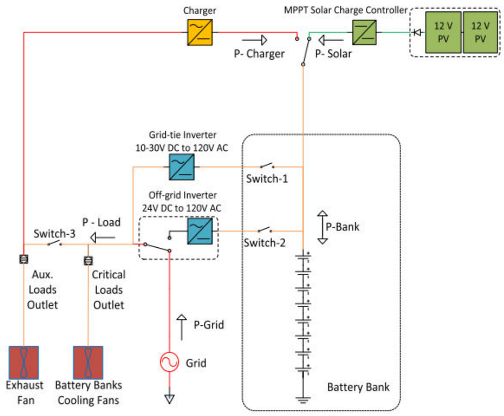


**Fig.1. Proposed model.**

## III METHODOLOGY

The total capacity of the storage system stays the same as the typical HESS in this approach. Since only one battery bank is going to be charged or discharged at a time, the power capacity of the system will be reduced by a factor of two. In order to keep the power rating at a constant level, the battery bank capacity can be doubled to ensure that the required power is available. This will increase the cost of the system, and however, in long term by extending the lifetime, may reduce the overall cost. The HESS controller continuously monitors several variables of the system, such as grid voltage, grid power, and consumed power by the loads in order to select the suitable mode of operation based on the TOU schedule. Fig. 4 shows the flowchart for the operation of the proposed HESS. For the proposed HESS, the following modes of operation are studied by using the MATLAB Simulink program for a 4-kW renewable HESS. Mode 1: During mid-peak hours, due to moderate electricity cost, the benefit of charging or discharging the battery banks is not significant. Therefore, the battery banks are disconnected from the charge and discharge circuits, and the SOC values stay constant. In this study, SW-7 will be turned on to convert any available solar energy to ac power via the grid-tie inverter without involving the battery banks. Fig. 5 shows the simulation results during mid-peak hours. The system controller enables the equalizing circuitry to balance the battery cells. However, when there is any solar energy available in this mode, free solar energy is used to reduce the grid power without storing it in the battery banks. The load and solar power values were changed suddenly for the purpose of simulation only. In this mode, the load power is set to 3000 W at the beginning, while there is 1000 W of solar energy available. Consequently, the grid power decreases to 2000 W. When there is no solar power, the grid provides about 3000 W as demanded by the load. Mode 2: During the course of on-peak hours, the stored energy in the battery banks will be converted to ac by means of the grid-tie inverter to reduce the grid power in order to lower the high electricity cost from the grid. Switches 1 and 3 or 2 and 4 are alternatively turned off or on to take advantage of the pulsed charge–discharge method. The system controller monitors and regulates the grid-tie inverter continuously to minimize the grid power under any load condition. Fig. 6 shows the simulation results during on-peak hours. In the beginning, the load is set to 3000 W; the grid-tie inverter generates 1000 W to reduce the incoming power from the grid system to 2000 W. The battery power charts show that one battery bank at a time provides the power to the grid-tie inverter. The battery power charts show the discharge of 1000 W for each battery bank. The SOC charts demonstrate that the state of charge values for both banks decrease consequently. Mode 3: During on-peak hours when the solar power exists, the battery banks get charged partially when the solar power is greater than the household loads power. When the harvested energy from solar panels is less than the loads' power, the gridtie inverter discharges the battery banks partially to reduce the energy cost imported from the power grid. Fig. 7 shows the simulation results during on-peak hours, while solar energy is available. When solar panels generate 2000 W, the load via grid-tie inverter consumes 1000 W of the solar energy, and the excessive 1000-W solar power is used to charge the battery banks alternatively. The SOC charts demonstrate the charge and discharge cycles accordingly. Mode 4: When the electricity cost is at its lowest rate during off-peak hours and there is no solar energy present, the grid powered battery charger charges the battery banks alternatively.

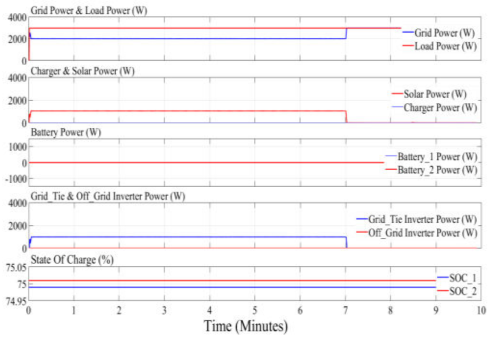


Fig. shows the simulation results during off-peak hours. A battery charger uses the grid power to charge the battery banks alternatively. In this simulation example, the battery charger is adjusted to provide 1000-W dc power continuously. The battery charger and other loads consume 2000 W from the grid. The SOC charts demonstrate that the SOC values increase due to the charging cycle. Mode 5: In this mode when a power outage happens, the off-grid inverter isolates the power grid from the household electrical circuits by means of its embedded transfer switch, based upon the amount of solar power availability; the batteries get charged or discharged alternatively. Fig. shows the simulation results during a power outage period. The off-grid inverter generates ac power to feed only the critical loads by discharging the battery banks alternatively when there is no solar energy available. The off-grid inverter discharges the battery banks to generate 1000 W to supply the critical loads. When solar panels generate 2000 W, the excessive 1000 W power is utilized to charge the battery banks alternatively. This can be observed from the battery banks power charts. Therefore, solar energy will extend the coverage time during a power outage. The SOC charts show the increase and decrease in SOC values during charge and discharge cycles.

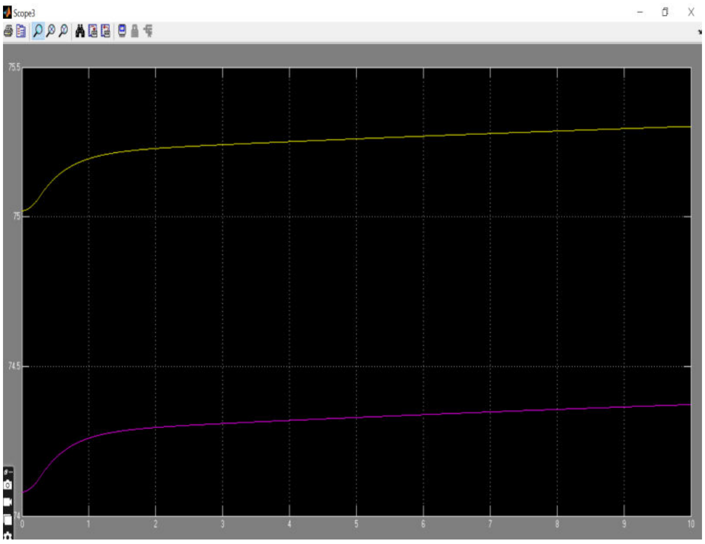

**Fig.2. Output results.**

## CONCLUSION

In this article, a new approach to extend the lifetime of the Li-ion batteries in an ESS for the household application was proposed and implemented. The proposed HESS utilizes the maximum available solar energy while extending the lifetime of the lithium-ion batteries. The simulation studies were performed to show the operation of the proposed HESS in different conditions. The stress test results show that the proposed configurations with the split-battery bank can extend the battery lifetime by about 24%.

## REFERANCES

[1] D. E. Olivares et al., “Trends in microgrid control,” IEEE Trans. Smart Grid, vol. 5, no. 4, pp. 1905–1919, Jul. 2014.

[2] R. L. Fares and M. E. Webber, “The impacts of storing solar energy in the home to reduce reliance on the utility,” Nature Energy, vol. 2, no. 2, p. 17001, Feb. 2017.

[3] D. Keles, T. Telsnig, B. Fleischer, M. Baumann, D. Fraboulet, A. Faure, W. Fichtner. (2015). Self-consumption of Electricity From Renewable Sources. INSIGHT_E. [Online]. Available: http://www.insightenergy.org/system/publications/files/000/000/016/ original/RREB6_self-consumption_renewable_electricity_final.pdf

[4] S. V. Kuchak, A. N. Voroshilov, and E. A. Chudinov, “Discharge characteristics of lithium-ion accumulators under different currents,” in Proc. 18th Int. Conf. Young Specialists Micro/Nanotechnol. Electron Devices (EDM), Jun. 2017.

[5] L. Wu, W. Kihinet, E. Robelo, E. Bezabith, K. Longwood, M. Saeedifard, T. Tshimanga, F. Lambert, R. Harley, “Development of a solar-power-based nanogrid system for village huts in Haiti mountain area,” in Proc. North Amer. Power Symp. (NAPS), Sep. 2016, pp. 1–5.

[6] X. Wu, X. Hu, X. Yin, and S. J. Moura, “Stochastic optimal energy management of smart home with PEV energy storage,” IEEE Trans. Smart Grid, vol. 9, no. 3, pp. 2065–2075, May 2018.

[7] Hydro One. (May 2018). Electricity Pricing and Costs’. Hydro One. [Online]. Available: https://www.hydroone.com/rates-and-billing/ratesand-charges/electricity-pricing-and-costs

[8] A. Safdarian, M. Fotuhi-Firuzabad, M. Lehtonen, and F. Aminifar, “Optimal electricity procurement in smart grids with autonomous distributed energy resources,” IEEE Trans. Smart Grid, vol. 6, no. 6, pp. 2975–2984, Nov. 2015.

[9] A. Mateo, J. A. Villarejo, J. Jimenez, and E. de Jodar, “Zero energy grid injection strategies using comercial inverters in solar energy power generation systems,” in Proc. Int. Conf. New Concepts Smart Cities: Fostering Public Private Alliances (SmartMILE), Dec. 2013, pp. 1–4.