PERFORMANCE ANALYSIS OF PV AND BESS BASED HYBRID SYSTEM FOR RESIDENTIAL LOAD

Pirthi Trehan[1], Tanu Puri[2]
[1&2]Baba Banda Singh Bahadur Engineering College, Fatehgarh Shahib, Punjab, India
[1]pirthitrehan93@gmail.com, [2]tanu.puri@bbsbec.ac.in

Abstract

Battery energy storage system (BESS) is installed along with solar photovoltaic (PV) to mitigate the intermittencies of solar output. In this paper, the model of hybrid system which is formed by the BESS in combination with photovoltaic (PV) power plant is presented. BESS is based on Lithium-ion technology and it is connected to DC bus by DC-DC power converter. Hybrid system is connected by DC-AC voltage source converter to the loads. The system advisor model (SAM) software developed by National Renewable Energy Laboratory (NREL) is utilized to simulate the results.

Index Terms: Photovoltaic, battery, energy storage, system advisor model.

I. INTRODUCTION

As energy systems transition to rely more on renewables and less on fossil fuels, we will also need to increase the capacity of energy storage. This is because most renewable energy resources provide an intermittent supply which can be at odds with demand. As a result, renewable installations paired with energy storage are expected to continue to well into the future. The installed capacity of energy storage is continuing to increase globally at an exponential rate. Global capacity doubled between 2017 and 2018 to 8 GWh [1]. Figure 1 portrayed the global installed energy storage capacity behind and In-front of the meter for years from 2013 to 2018 taken from [2].

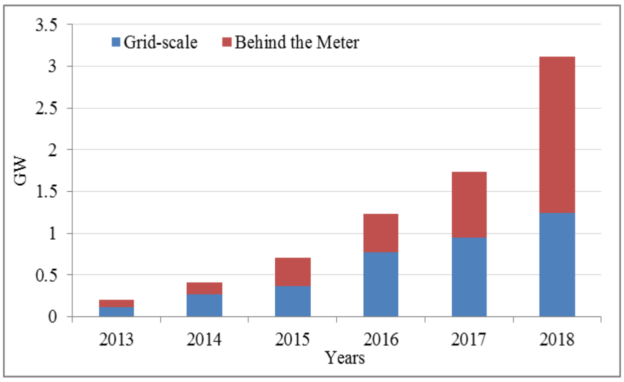

Figure 1: Global installed energy storage capacity behind and In-front of the meter [2].

As renewables become more prevalent on distributed networks and production more localized, smarter controlling and market mechanisms are evolving to enable energy storage to offer ancillary services which improve reliability of supply [3]. Energy storage systems provide a wide array of technological approaches for managing power supply in order to create a more resilient energy infrastructure and bring cost savings to utilities and consumers. The energy storage systems are categorized into mechanical, electrochemical, chemical, electrical, and thermal [4], [5].

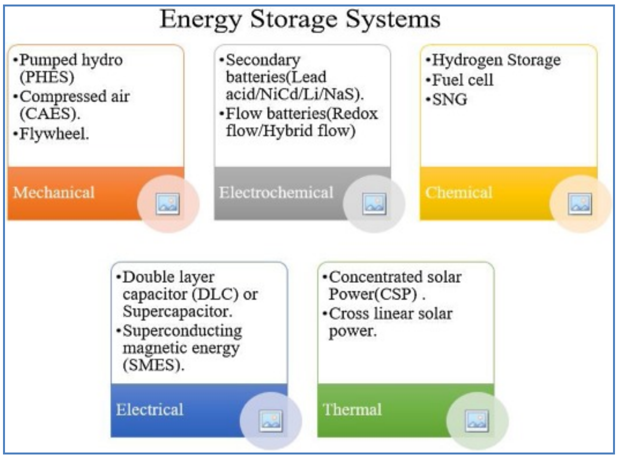

Figure 2: Categorization of Electricity Storage Systems [4]

In this paper, modeling of the photovoltaic-battery hybrid system is presented to achieve stable and controllable power output. In next section, every part and control of the system is described in detail. Section 3 deals with the simulation of proposed system and highlights the results of simulated scenarios followed by concluding remarks in section 4.

II. HYBRID SYSTEM MODELING

Battery energy storage systems (BESS) will most likely play an important role in enabling integration of small scale renewable energy sources, from residential and grid connected power systems, into the electricity networks. This paper focuses on electrical energy storage systems, especially battery energy storage systems for grid connected electrical power systems [6], [7].

In order to operate the distributed power supply system in an autonomous mode with a high efficiency and to ensure an effective continual power supply throughout the year, an energy storage element is always required as an energy buffer. Furthermore, it also has a significant impact upon improving power quality of distributed generation systems [6], [8], [9]. In this study, the lithium-ion technology based battery is used in energy storage unit.

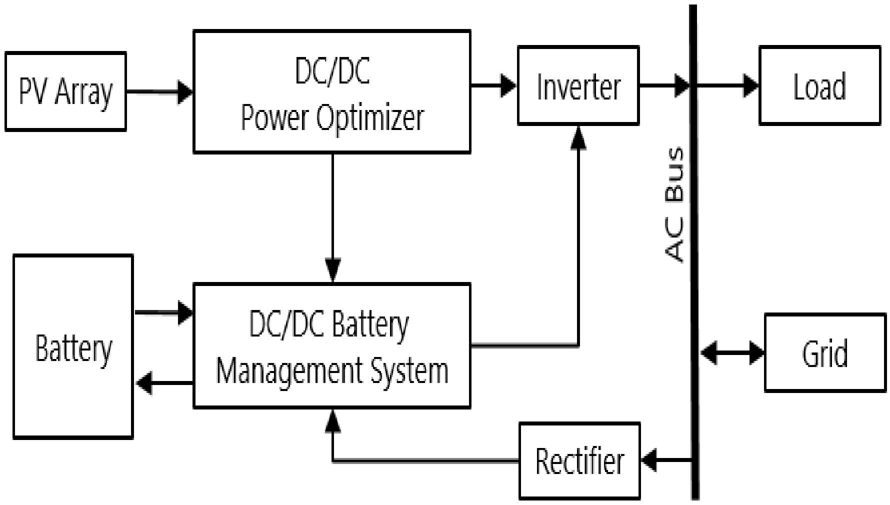

Figure 3: Hybrid system model implemented in system advisor model (SAM)

Figure 3 shows the configuration of the grid-connected PV/Battery power generation system. PV array and battery are connected to the common DC link via a DC/DC boost converter and DC/DC bidirectional converter respectively, and then interconnected to the AC grid via a common DC/AC inverter. For the two-stage PV system, the maximum power point tracking is realized by controlling the DC/DC boost converter [10]. The DC/DC boost converter (step up) serves the purpose of transferring maximum power from the solar PV module to the DC link. The DC/DC boost converter acts as an interface between the inverter [6],[11]–[13].

III. RESULTS AND DISCUSSION

The presented hybrid PV and BESS model is assessed in the system advisor model (SAM) free software developed by National Renewable Energy Laboratory (NREL). In SAM, the modeling is done for residential load purpose and location (Patiala, India) is chosen from the predefined library for weather data. Furthermore, system is designed by considering two parallel strings having seven modules per string and a DC/AC inverter is connected. Lithium-ion technology based (Nickel Manganese Cobalt Oxide) battery is utilized for energy storage purpose.

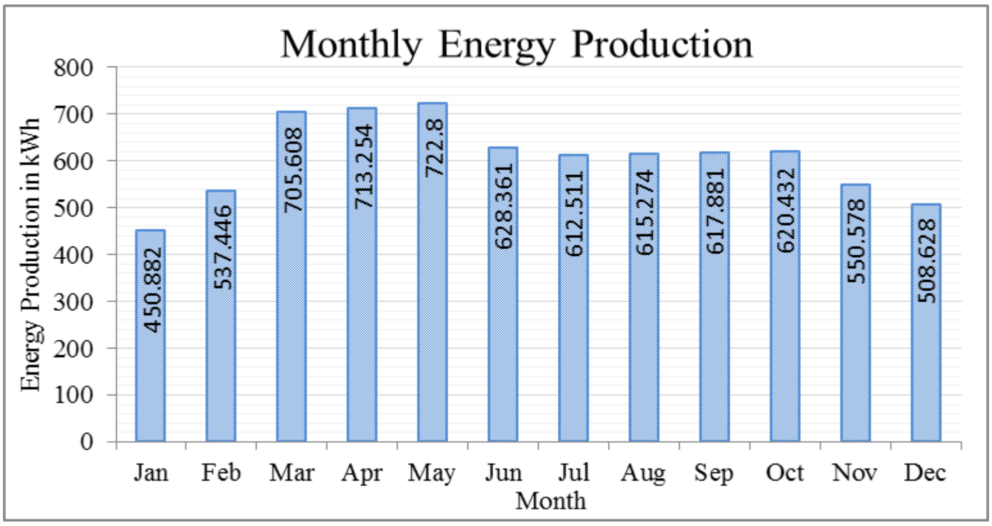

Figure 4: Month wise energy production in kWh

Figure 4 graphically presents the month wise energy generation (in kWh) from the system. It can be observed that the maximum energy 722.8 kWh is produced in month of May which is followed by 713.25kWh in month of April. In January, energy generation is least and is equal to 450.88 kWh. Month wise energy generation and load is compared in figure 5. Cumulative energy credit earned is also portraying in figure 5. At the end of year total energy credit earned is 1236.76 kWh.

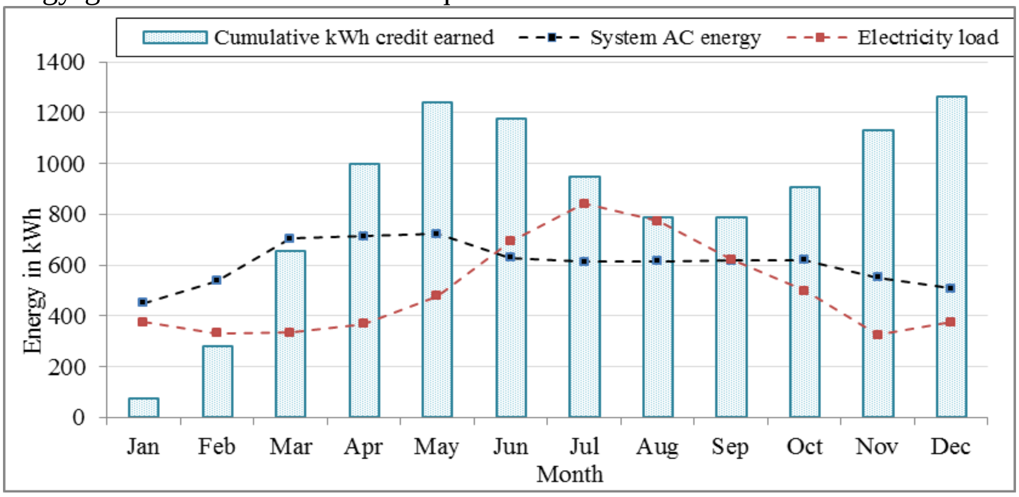

Figure 5: Monthly energy and load graph

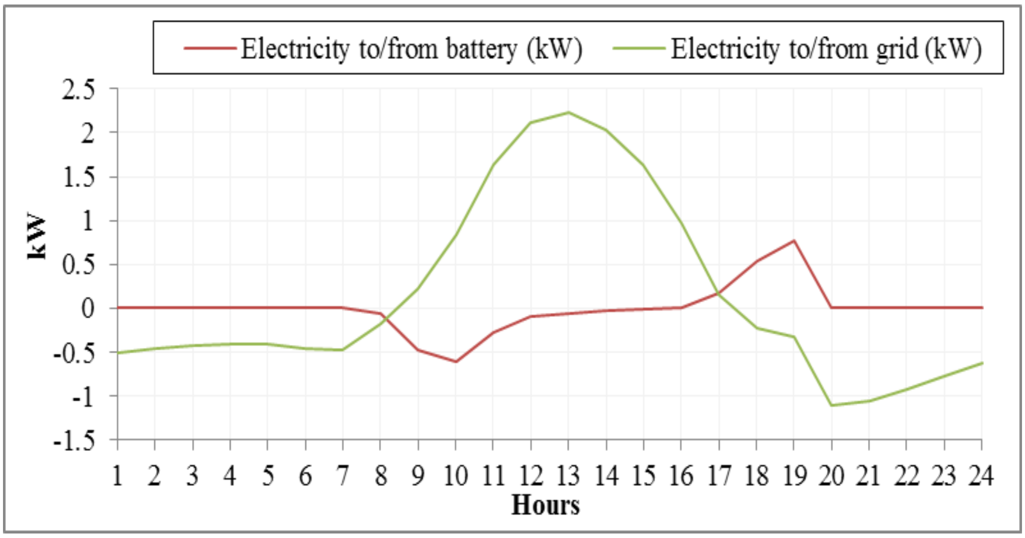

Figure 6: Hourly electricity to/from battery and grid in kW

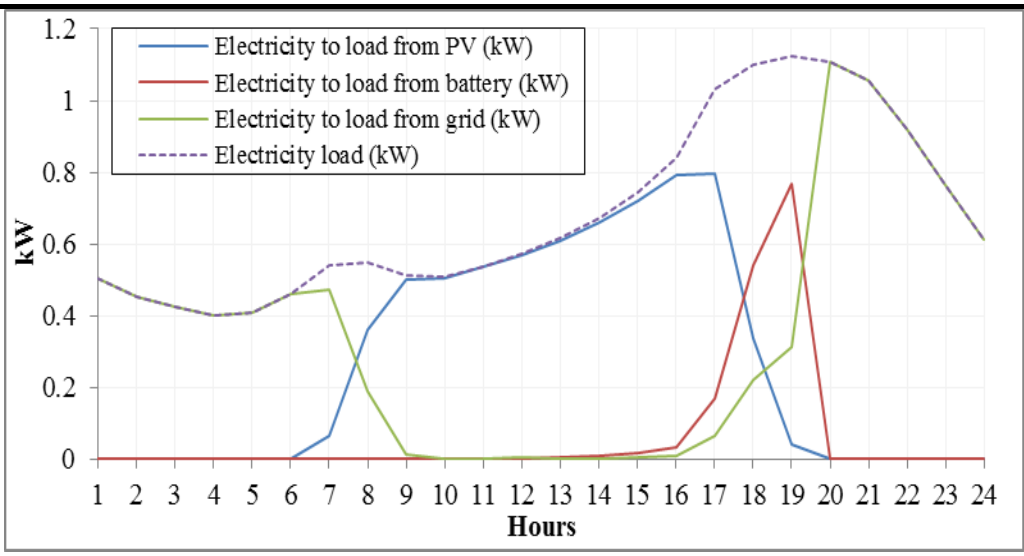

Figure 7: Hourly electricity to load from PV, battery and grid and total load in kW

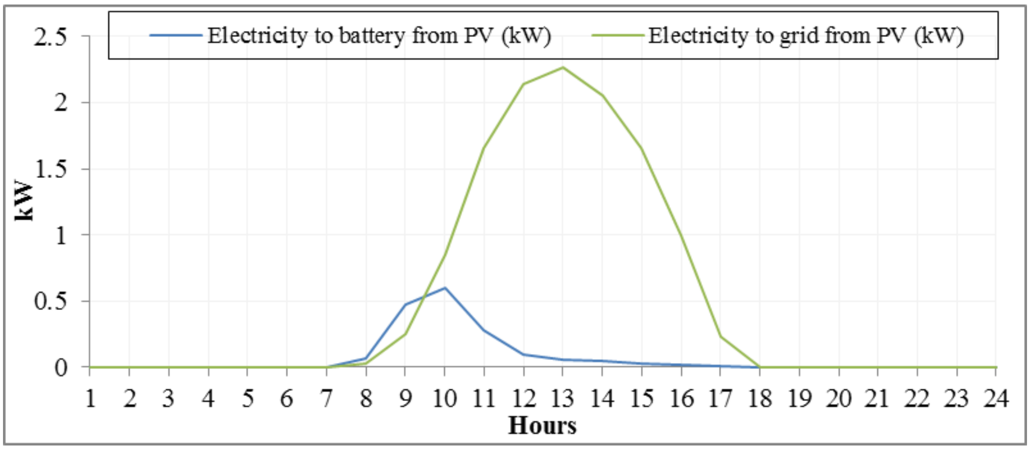

Figure 8: Hourly electricity to battery and grid from PV in kW

Various obtained results are depicted in figures 6 to 8. Figure 6 shows electricity injected or taken out from battery and grid in kilo-watt on hourly basis, while load is fed from the PV directly or supplied through the battery or grid is graphed in figure 7. Electricity is supplied to battery or grid is pictured in figure 8. From the obtained results it can be said that net saving on electricity bills will be about $ 757 by installing the hybrid system as compare to without system.

IV. CONCLUSION

The battery energy storage system (BESS) has witnessed an incremental market growth in the recent years due to their continual improvements which have also contributed to the extension of their applications range. Simulation results prove that the grid-connected PV/BESS generation system improves the PV utilization and provides stable and reliable power for loads or power grid during its operation modes.

REFERENCES

[1] W. E. Council, "Energy Storage Monitor Latest trends in energy storage: 2019," 2019.

[2] W. E. Resources, "E-storage : Shifting from cost to value Wind and solar applications," 2016.

[3] Deloitte, "Energy storage: Tracking the technologies that will transform the power sector," 2015.

[4] A. Kumar, K. Priyalakshmi, and S. Rangnekar, "An overview of energy storage and its importance in Indian renewable energy sector Part I – Technologies and Comparison," *J. Energy Storage*, vol. 13, pp. 10–23, 2017.

[5] E. O. Ogunniyi and H. Pienaar, "Overview of Battery Energy Storage System Advancement for Renewable (Photovoltaic) Energy Applications," in *2017 International Conference on the Domestic*

Use of Energy (DUE), 2017.

[6] Y. Kircicek, A. Aktas, and M. Ucar, "Modeling and Analysis of a Battery Energy Storage System Supplied from Photovoltaic Power Source," in *7th International Ege Energy Symposium & Exhibition*, 2014, pp. 1–13.

[7] N. C. Nair and N. Garimella, "Battery energy storage systems : Assessment for small-scale renewable energy integration," *Energy Build.*, vol. 42, no. 11, pp. 2124–2130, 2010.

[8] T. Xia, M. Li, P. Zi, L. Tian, X. Qin, and N. An, "Modeling and Simulation of Battery Energy Storage System (BESS) Used in Power System," in *5th international conference on Electric Utility Deregulation and Restructuring and Power Technologies November*, 2015, pp. 2120–2125.

[9] X. Xu, M. Bishop, D. G. Oikarinen, and C. Hao, "Application and Modeling of Battery Energy Storage in Power Systems," *CSEE J. POWER ENERGY Syst.*, vol. 2, no. 3, pp. 82–90, 2016.

[10] R. Singh, S. Taghizadeh, N. Mei, L. Tan, and J. Pasupuleti, "Battery Energy Storage System for PV Output Power Leveling Advances in Power Electronics," *Adv. Power Electron.*, vol. 2014, pp. 1–14, 2014.

[11] G. Subramani, V. K. Ramachandramurthy, P. Sanjeevanikumar, L. Mihet-Popa, F. Blaabjerg, and J. M. Guerrero, "Grid-Tied Photovoltaic and Battery Storage Systems with Malaysian Electricity Tariff - A review on Maximum demand Shaving," *Energies, MDPI*, vol. 10, pp. 1884–1900, 2017.

[12] F. Mohamad, J. Teh, C.-M. Lai, and L.-R. Chen, "Development of Energy Storage Systems for Power Network Reliability : A Review," *Energies, MDPI*, vol. 11, pp. 2278–2296, 2018.

[13] T. M. Jackson and G. R. Walker, "Integrating PV systems into distribution networks with Battery Energy Storage Systems," in *AUPEC 2014*, pp. 1–7, 2014.