Engineering and Technology Journal for Research and Innovation (ETJRI)
ISSN 2581-8678, Volume II, Issue II

Optimal Scheduling of Solar PV Connected Microgrid

Ashutosh Barua[1], Arvind Kumar Jain[2], Pankaj Kumar Mishra[3] and Divya Singh[4]
[1]*Department of ECE,* [2]*Department of Electrical Engineering, National Institute of Technology Agartala*
[3]*Department of Applied Physics,* [4]*Department of Chemistry, Amity School of Engineering & Technology, Amity University Madhya Pradesh, Maharajpura Dang, Gwalior(MP)-474005,*
abarua@gwa.amity.edu[1]*,pmishra@gwa.amity.edu*[3]*, dsingh@gwa.amity.edu*[4]

***Abstract*— Microgrid provides electricity to the grid-connected as well as the remote location areas. Renewable energy like solar can provides clean electric power to the connected microgrid. In this paper, a model is proposed for an off-grid microgrid. Parameters of the equipment connected in the microgrid are studied. In the end, optimal scheduling of microgrid connected to solar photovoltaic is done with the islanded microgrid. Its environmental impact is also calculated in the proposed model.**

***Keywords*—Microgrid, Solar PV, HOMER, Islanded microgrid**

I. INTRODUCTION

Energy demand is increasing exponentially, requiring energy resources to meet these requirements, causing potential pollution of the atmosphere and global warming[1]. On the other hand, renewables today are pure Limitless sources of energy attracting the researchers[2].

Remote areas and some of the villages are still facing the issue related to the reliability of power supply in their houses[3]. To overcome this problem most of the Indian villages are connected to the centralized grid but still, there is lack of power supply which can be met by using a microgrid connected with the power generated locally with in the area[4]. Connecting microgrid with renewable energy is a viable and beneficial solution to the problem, but at the same time, optimal scheduling of power sources is important[5].

There are two types of microgrid on the basis of connection to the main grid[6]. Microgrid connected to the main grid along with distributed power sources located nearby the microgrid is known as a grid-connected microgrid[7]. The microgrid modelled in this study is an islanded microgrid. An islanded microgrid is not connected to the main grid[8], as islanded microgrid can to be used in rural, India, to meet demand[9]. The reason for selecting a microgrid is due to the fact that there is currently no distribution network at the site, so the special line that leads to it would require a large investment[10]. An autonomous microgrid would certainly entail some investment, but from the point of view of energy usage being free during the project, it would be more efficient than constructing a near-distribution substation line[11]. Furthermore, microgrid which are primarily based on renewable energy sources can help minimize greenhouse gas emissions and thereby create a better environment[12][13].

In this paper, an islanded microgrid is considered in Madhya Pradesh region, the average solar irradiance of this area is 5.61 kWh/m2/day taken into consideration[14]. Solar Photovoltaic (PV) modules are considered as a supplementary source of electrical power in addition to the diesel generator, which is connected as a base power source to the islanded microgrid. A load of a residential area having 5kWh/day load. Consisting of basic loads like illumination, fan, television to meet the day-to-day requirement.

Simulation of islanded microgrid model is completed using HOMER software. The daily load profile is provided as an input in the software combined to form monthly data. Peak loads are considered in the simulation. Environmental data like solar irradiance, wind speed and temperature were taken from National Renewable Energy Laboratory[15].

This paper discusses the model of the islanded microgrid in section II, parameters of peak load demand and solar are discussed in section III, IV

section deals with the calculation of harmful gases in the environment.

II. Islanded Microgrid Model

Modelling of an islanded microgrid is represented in fig.1. For the rural area. The residential load considered with Solar PV of 300W connected with an islanded microgrid. A diesel generator is taken as a base power source, a lead-acid battery of 1kWh is taken as an energy storage device for the microgrid. In the daytime when solar PV produces electrical power, this power can be stored in the lead-acid battery connected on the DC bus. Two busses are also considered for connection purpose. Diesel generator, solar PV modules and AC loads connected on AC bus and batteries are connected on DC bus. Converters are considered into account so that power can be converted from AC to DC and vice-versa. The converter includes rectifiers and inverters. When power needs to be transferred from AC bus to DC bus rectifier are used and when it is transferred in the opposite direction, it acts as an inverter.

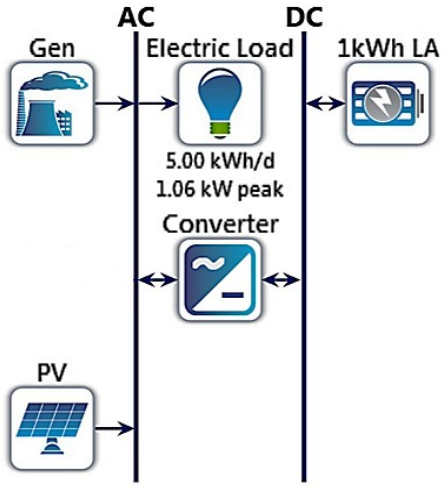

Fig.1. Solar PV Connected Microgrid

III. Peak Load Demand And Solar PV

The residential load of basic electrical equipment connected to the microgrid like Fans, LED bulbs, television is 5kWh/day. Demand is also not fixed as different types of equipment are switched on and off in at a different time. However, peak demand can be determined for a particular interval of time. In the simulated model, the peak demand graph is increasing form the month of January to June and decreases until December. It is minimum in the month of December to January and maximum in the month of May and June as represented in fig.2.

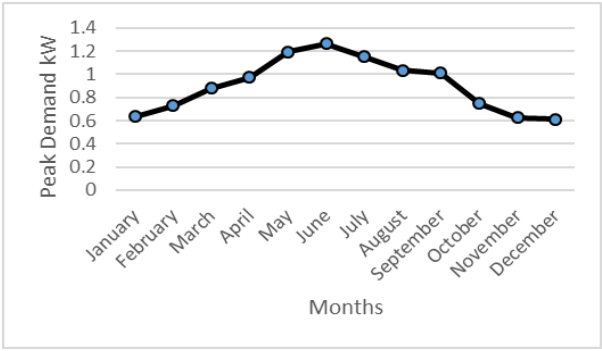

Fig. 2. Peak Demand

In the proposed microgrid modelling, optimal scheduling is done by using a generic solar PV module of 570W. PV penetration of the PV module is 23.2%. it will operate 4,364hrs/year as in Table I. Power produced by the solar PV is not constant as solar irradiance is dependent on the climatic condition throughout the year[16]. In cloudy days solar irradiance is at a minimum value and in summer noon with clear clouds, it attains its maximum peak[12].

TABLE I
GENERIC SOLAR PV ELECTRICAL SUMMARY

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	0.570	kW
PV Penetration	23.2	%
Hours of Operation	4,364	hrs/yr
Levelized Cost	0.0910	$/kWh

Total production per year by 570W solar PV module is 1180kWh/yr as shown in table III, other parameters such as rated capacity, mean output, capacity factor are also calculated.

TABLE II
GENERIC SOLAR PV STATISTICS

Quantity	Value	Units
Rated Capacity	0.570	kW
Mean Output	0.124	kW
Mean Output	3.85	kWh/d
Capacity Factor	17.9	%
Total Production	1180	kWh/yr

Fig. 3 represents the Solar PV output, i.e the output power is given by the solar PV module during 24hrs for the complete one year. As per the graph, it is maximum in the summers and minimum in the rainy season.

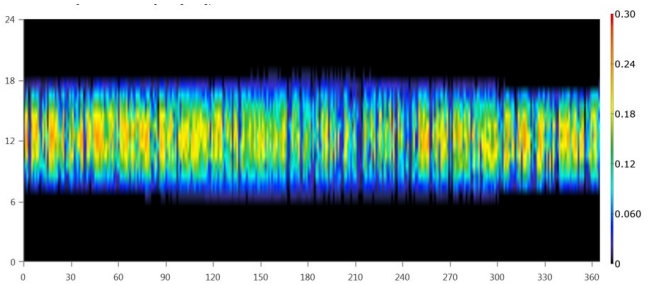

Fig. 3. Generic Solar PV Output (kW)

IV. Emission of Harmful Gases

Various types of harmful gases are produced by the diesel generator[17][18]. Fossil fuels are limited on earth. Connection solar PV to the microgrid will not only shares the load but also beneficial for the environment[19]. The reduced harmful gases are calculated in the simulated model, details of the various types of gases with their emissions in kg/year are shown in Table III.

TABLE III
Total Emissions

Pollutant	Quantity	Unit
Carbon Dioxide	912	kg/yr
Carbon Monoxide	0	kg/yr
Unburned Hydrocarbons	0	kg/yr
Particulate Matter	0	kg/yr
Sulfur Dioxide	4.97	kg/yr
Nitrogen Oxides	1.98	kg/yr

V. Conclusion

Solar PV, as a power generating source integrated with a microgrid, is a better solution for an islanded microgrid with the residential load connected to it. Optimal scheduling of solar PV with a diesel generator in an islanded microgrid can be concluded from the table I. Solar PV supports the islanded microgrid as observed in table II. The detailed results are shown in Fig.3. Environmental impact of the microgrid is also studied. Harmful gases creating pollution in the environment are calculated in TABLE III for the simulated model. These results will be helpful in modelling and planning of island microgrid with solar PV, for balancing the electrical power demand by the consumers.

References

[1] A. Kumar, A. R. Singh, Y. Deng, X. He, P. Kumar, and R. C. Bansal, "Multiyear load growth based techno-financial evaluation of a microgrid for an academic institution," *IEEE Access*, vol. 6, pp. 37533–37555, 2018.

[2] O. Hafez and K. Bhattacharya, "Optimal planning and design of a renewable energy based supply system for microgrids," *Renew. Energy*, vol. 45, pp. 7–15, 2012.

[3] R. Tongia, "Microgrids in India," *Brookings*, no. May, pp. 47–55, 2019.

[4] S. Bahramara, M. P. Moghaddam, and M. R. Haghifam, "Optimal planning of hybrid renewable energy systems using HOMER : A review," *Renew. Sustain. Energy Rev.*, vol. 62, pp. 609–620, 2016.

[5] N. K. Meena, J. Yang, and E. Zacharis, "Optimisation framework for the design and operation of open-market urban and remote community microgrids," *Appl. Energy*, vol. 252, no. March, p. 113399, 2019.

[6] L. Mariam, M. Basu, and M. F. Conlon, "Microgrid: Architecture, policy and future trends," *Renew. Sustain. Energy Rev.*, vol. 64, pp. 477–489, 2016.

[7] S. Mizani and A. Yazdani, "Optimal design and operation of a grid-connected microgrid," *2009 IEEE Electr. Power Energy Conf. EPEC 2009*, no. 3, pp. 1–6, 2009.

[8] N. Hatziargyriou, *Microgrids: Architectures and Control*. 2013.

[9] A. Jhunjhunwala and P. Kaur, "Solar energy, dc distribution, and microgrids: Ensuring quality power in Rural India," *IEEE Electrif. Mag.*, vol. 6, no. 4, pp. 32–39, 2018.

[10] E. Hossain, E. Kabalci, R. Bayindir, and R. Perez, "Microgrid testbeds around the world: State of art," *Energy Convers. Manag.*, vol. 86, pp. 132–153, 2014.

[11] A. Kumar, A. R. Singh, Y. Deng, X. He, P. Kumar, and R. C. Bansal, "Integrated assessment of a sustainable microgrid for a remote village in hilly region," *Energy Convers. Manag.*, vol. 180, no. October 2018, pp. 442–472, 2019.

[12] S. Bahramara *et al.*, "Solar Radiant Solar Radiant Energy," *Renew. Sustain. Energy Rev.*, vol. 6, no. 1, pp. 2217–2235, 2019.

[13] R. Wang, C. M. Lam, S. C. Hsu, and J. H. Chen, "Life cycle assessment and energy payback time of a standalone hybrid renewable energy commercial microgrid: A case study of Town Island in Hong Kong," *Appl. Energy*, vol. 250, no. April, pp. 760–775, 2019.

[14] A. Barua, A. K. Jain, M. Gupta, and P. K. Mishra, "Control and techno-economic analysis of PV-diesel-

battery based hybrid microgrid system," 2017 Conf. Inf. Commun. Technol. CICT 2017, vol. 2018-April, pp. 1–5, 2018.

[15] A. W. L. Lim, T. T. Teo, M. Ramadan, T. Logenthiran, and V. T. Phan, "Optimum long-term planning for microgrid," IEEE Reg. 10 Annu. Int. Conf. Proceedings/TENCON, vol. 2017-Decem, pp. 1457–1462, 2017.

[16] C. Avilés A., S. Oliva H., and D. Watts, "Single-dwelling and community renewable microgrids: Optimal sizing and energy management for new business models," Appl. Energy, vol. 254, no. March, p. 113665, 2019.

[17] Y. Sawle, S. C. Gupta, and A. K. Bohre, "Review of hybrid renewable energy systems with comparative analysis of off-grid hybrid system," Renewable and Sustainable Energy Reviews, vol. 81, no. May. Elsevier Ltd, pp. 2217–2235, 2018.

[18] H. U. R. Habib, S. Wang, M. R. Elkadeem, and M. F. Elmorshedy, "Design Optimization and Model Predictive Control of a Standalone Hybrid Renewable Energy System: A Case Study on a Small Residential Load in Pakistan," IEEE Access, vol. PP, pp. 1–1, 2019.

[19] L. Tripathi, A. K. Mishra, A. K. Dubey, C. B. Tripathi, and P. Baredar, "Renewable energy: An overview on its contribution in current energy scenario of India," Renew. Sustain. Energy Rev., vol. 60, pp. 226–233, 2016.