ID 1093

Simulation of Microgrid Operation for the Evaluation of Economic, Technical, and Environmental Performances: The Case of Urban Application in Algeria

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ABSTRACT

Clean and renewable energy sources have been traditionally considered as a cost effective alternative for energy generation in remote areas since they are more economically viable than grid extensions. Nowadays, their integration in urban areas has become a key requirement to improve the reliability of the existing utility grid and to solve emissions and climate change issues. The present paper deals with the design, the optimization, and the economic viability of an urban microgrid intended to meet electrical needs of a typical load and under real meteorological conditions. In addition, a comparative study of different configurations of the microgrid (PV, wind, Diesel generator, batteries, grid) based on the analysis of the three criteria including reliability, cost-effectiveness, and environmental sustainability has been proposed to analyze the operational strategy and to control the power flow between the system components.

Keywords: Microgrid, Cost-effective, Optimization, HOMER Pro.

1. Introduction

Microgrids have emerged as a new kind of grid in the power systems field, where distributed energy resources (DERs) take a fundamental role. Microgrids make possible diversity in power sources and allow penetration of renewable energy. The complexity of microgrids and the mix of elements which compose them make investment studies especially important; errors in investing and sizing elements in microgrids may arise in huge not needed costs because of the high price of microgrid components. Therefore, before starting a microgrid project it is crucial to make sure the profitability of it and measure it. In that way the investment optimization lowers the risk of implementing microgrids [1-2]. A detailed techno-economic study of a microgrid involves analyzing technical, economic and environmental aspects of implementing and operating the microgrid system [3-4]. Through a detailed case study, we examine a real-world microgrid scenario, analyzing different configurations and scenarios to assess their performance under varying conditions. This study aims to investigate the viability and optimization potential of microgrid to cover the energy consumption of a typical load taking into account the meteorological resources available in the city of BouIsmail, Tipaza, Algeria. using HOMER Pro software.

2. Experimental

HOMER Pro is used as an optimization tool for this analysis. It is used to simulate various schematics of power plants and then those schematics are simulated to find most optimized power plant configuration with respect to operating cost, net present cost (NPC), gases emission and economic comparison. A ranking technique has been used to determine and design the best optimum system.

3. Results and Discussion

After conducting extensive simulations and optimizations using HOMER Pro, the results that shed light on the performance and feasibility of two microgrid configurations. The first case includes the combination of (PV/wind/batteries/DG/grid) and the second case reveals the combination of (PV/wind/batteries/grid). The optimal solutions are depicted in Table 1. Simulation results over two days of operation, employing two energy management strategies (LF and CC) for each configuration to ensure power balance among renewable sources, batteries, diesel generators, and the grid, are shown in figure 2 and figure 3.

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DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

These results are sorted in such a way that the second case is the cost-effective in terms of cost of energy, total net present cost and gases emissions while the first case has the highest values for all these parameters.

Table 1: *Optimum configuration of the microgrid*

PV (kW)	Wind (kW)	DG (kW)	Battery	Grid (kW)	Dispatch strategy	Total NPC ($)	COE ($/kWh)	RF (%)	CO2(kg)
4	1	10	24	2	LF	51,406	0.315	0.65	5205
4	1	0	24	8	CC	47,930	0.293	0.71	2645

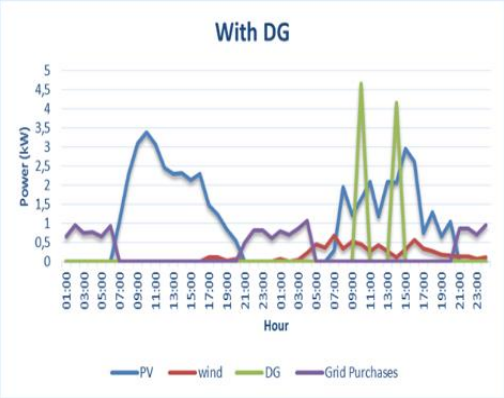

Figure 1: Power scheduling for case 1

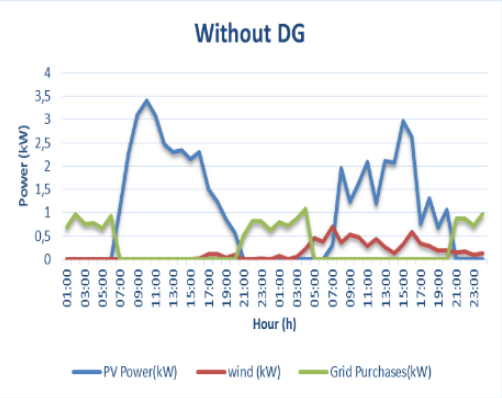

Figure 2: Power scheduling for case 2

4. Conclusions

The main challenge Microgrids is to ensure proper energy management. Therefore, an energy management strategy must be implemented to match supply with demand. These systems need to be financially viable, technically reliable and environmentally sustainable. In this paper, the analysis was performed in order to decide which optimization will be beneficial to cover the energy consumption taking into account the meteorological resources available in the city of BouIsmail, Tipaza, Algeria. Comparing the optimization results of the (PV, wind, Diesel generator, batteries, conventional grid) and (PV, wind, batteries, conventional grid) system shows that the second case is the cost-effective in terms of cost of energy, net present cost and gases emissions. In addition, the obtained results show a great reduction of pollution gas emissions for the case without DG. This helps, among other things, to:

- Minimization of electricity production cost.
- Environmental performance (CO_2 emissions and Renewable Factor).
- Enhanced utilization of renewable energy (solar and wind).
- Minimization of reliance on the main grid and diesel generator (conventional energy sources).

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ISBN: 978-81-970666-4-1
Series: AIJR Abstracts
DOI: 10.21467/abstracts.169