Economic Operation of Grid-Connected Microgrid By Multiverse Optimization Algorithm

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2019

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Abstract: In this paper, a new optimization algorithm known as the Multiverse Optimization Algorithm (MOA) is developed for optimal economic operation of the micrigrid (MG) in the grid-connected mode. Results shows the merit of the proposed technique.

I. INTRODUCTION

Microgrid (MG) is the summation of the loads and distributed energy resources (DERs) in a small electricity grids [1-5]. MG has some benefits such as higher reliability, resiliency, and voltage problem, as well as the less operation cost. This is due to closeness to the consumers, that can lead to less transmission lines. [6-7]. The energy management of the MG is a mixed-integer problem, which is hard to solve. This problem is investigated in some researches so far. However, develop a powerful solution algorithm is vital in the energy management of the MG [8-11]. This paper proposes a new evolutionary algorithm known as the multiverse optimization algorithm to overcome the complexity of the energy management of the grid-connected MG operation. The proposed technique is more efficient than the well-known techniques, e.g., particle swarm optimization (PSO), teaching learning based optimization (TLBO), and genetic algorithm [12-14].

II. MICROGRID GRID-CONNECTED FORMULATIONS

A. Objective function

The main objective is to minimize the total operation cost as

$$min \sum_{\forall i}[C_i P_{it} I_{it} + SU_{it} + SD_{it}] \quad (1)$$

In which:

I is a binary variable (0 or 1) that controls the status of unit *i* at time *t.*

SU and *SD* are the startup and shutdown costs.

In this paper, the following nomenclature is used:

UT and DT are minimum up and down

$T_{(on)}$ and $T_{(off)}$ are the number of successive on and off hours

RU and *RD* are the ramp up and down of the generators.

B. Constraints

There exist some constraints associated with the MG grid-connected energy management as follows.

1. Generation unit's capacities

$$P_{it,min} \leq P_{it} \leq P_{it,max} \quad (2)$$

2. Generation units ramp up and down limitations

$$P_{it} - P_{i(t-1)} \leq RU_i \quad (3)$$

$$P_{i(t-1)} - P_{it} \leq RD_i \quad (4)$$

3. Generation units minimum up and down time

$$T_{(on)it} \geq UT_i(I_{it} - I_{i(t-1)} \quad (5)$$

$$T_{(off)it} \geq DT_i(I_{i(t-1)} - I_{it} \quad (6)$$

III. Multiverse Algorithm

This paper utilized a new evolutionary algorithm known as the multiverse evolutionary algorithm to overcome the complexity of the problem due to the integer variable of the generation units. This method is taken form [12]. In comparison with the well-known methods, e.g., particle swarm optimization (PSO) and genetic algorithm (GA), the proposed technique has higher accuracy and speed. It should be noted that these techniques have been used in many fields [16-19].

IV. Simulation Results

To demonstrate the economic merit of the proposed technique, the modified IEEE 69 bus test system is selected and tested. Fig. 1 depicts the single line diagram of the model

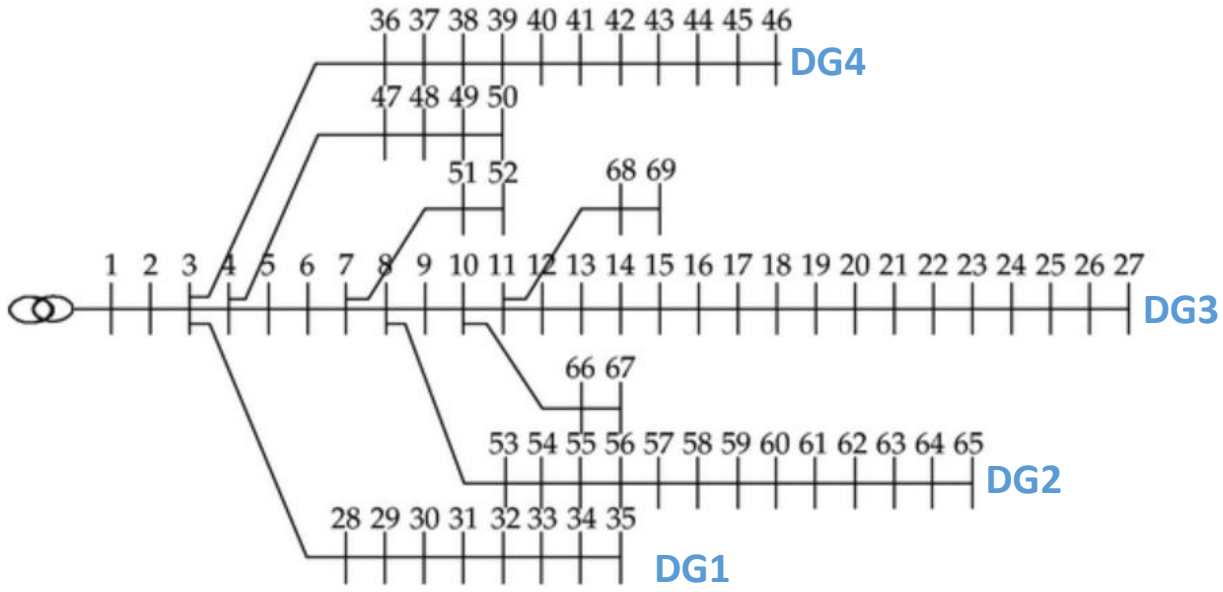

Fig. 1. IEEE 69 bus test system diagram

Also, table I presents the DGs features within the grid, followed by the day-ahead load demand in Fig. 2.

Table I
DGs features

	Minimum output power	Maximum output power
DG1	20	400
DG2	40	450
DG3	10	250
DG4	10	250

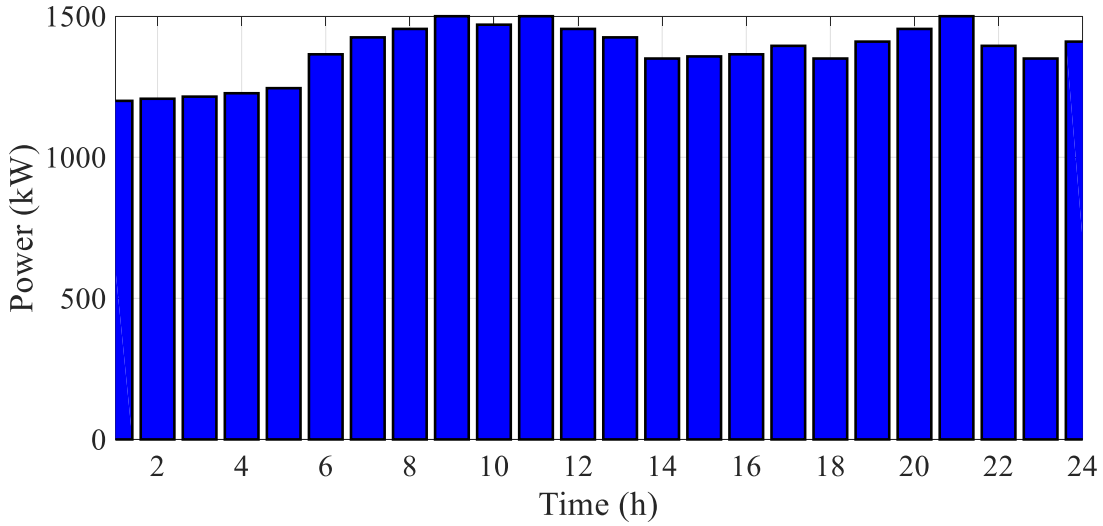

Fig. 2. Microgrid load demand

The optimal output powers of the DGs are depicted in Fig. 3. According to the results the cheapest units are more committed than others. This can prove the economic aspects of the proposed method. Also, the main grid sell energy to the MG in the hours that the market price is lower than the DGs price.

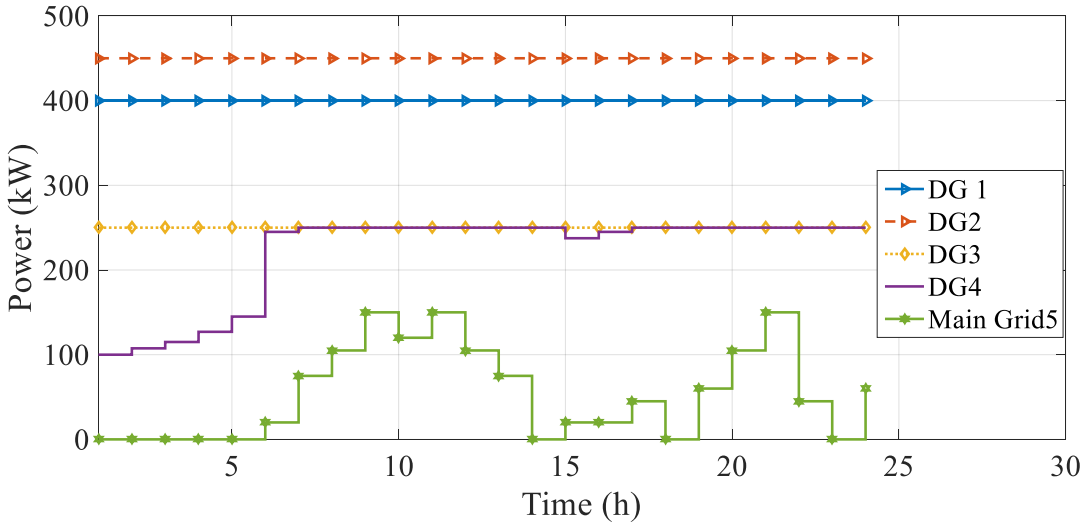

Fig. 3. Produced powers by DGs

To demonstrates the economic merit, as well as the convergence speed of the algorithm, it has been compared with the PSO and GA. These are reported in Table II. Based on this table, the convergence speed and operation cost of the grid-connected MG under the proposed technique is very lower than others.

Table II

Cost of operation for several methods

	cost ($)	Convergence (s)
PSO	637335	11.1
GA	623437	9.9
Proposed method	598834	7.6

V. Conclusion

In this paper a new optimization algorithm known as the multiverse optimization algorithm is developed for grid-connected MG energy management. This algorithm is compared with the well-known algorithms such as PSO and GA. Results show the

economic merit and also high convergence speed of the proposed technique, as two main factor in utilities economic operations.

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