Self- Supplied Microgrid Economic Scheduling Based on Modified Multiverse Evolutionary Algorithm

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Abstract: In this paper, a new evolutionary algorithm, known as the multiverse evolutionary algorithm (MEA) is developed for self-supplied microgrid operation. To show the effectiveness of the proposed method, it has been tested on the modified IEEE 33 bus test system. Results demonstrates the economic merit of the proposed technique.

I. Introduction

Recently, microgrids (MG) is very attractive due to some importance benefits such as closeness to the consumers, that can lead to higher reliability of the network [1-5]. MG can be connected to the main grid and also has potential to be disconnected from the main grid. In the case that the MG is disconnected, the distributed generators (DGs) should satisfy the load [6-10]. This case is known as the islanded mode where the MG is in the self-supplied mode. MG can be disconnected due to the technical problem in the main grid, or due to the economic benefits [11]. However, the energy management, cybersecurity, and protection of the MG would be more challenging [12-14]. MG is a mixed-integer non-linear problem (MINLP), which is hard to solve. Hence, this paper proposed a new evolutionary algorithm to solve the problem.

II. PROBLEM FORMULATIONS

The proposed problem has an objective function, as

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

Here, *I* is a binary variable that can be zero or one and determine the status of unit *i* at time *t. SU* and *SD* are the startup and shutdown costs of the *i*th unit at time *t*.

Also, there exist some constraints associated with the problem. For instance, the capacity of the DGs should be within limits as

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

Here, *P* is the output power of DGs.

In addition, the limitation on the ramp up and down of generators are as:

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

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

Where:

RU_i and RU_i are the ramp up and ramp down rates of the *i*th generation units, respectively.

Finally, the minimum up and down time limits are considered as:

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

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

Where:

UT_i and DT_i are minimum up and down rates of the *i*th unit.

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

This paper utilized a new evolutionary algorithm known as the multiverse evolutionary algorithm. This method is taken form [15]. Compared to the well-known methods such as

particle swarm optimization (PSO) and genetic algorithm (GA), the proposed technique has higher accuracy and speed.

III. RESULTS

Figure 1 depicts the diagram of the modified IEEE 33 bus test system. The network consist of 4 DGs. DGs characteristics are shown in Table I.

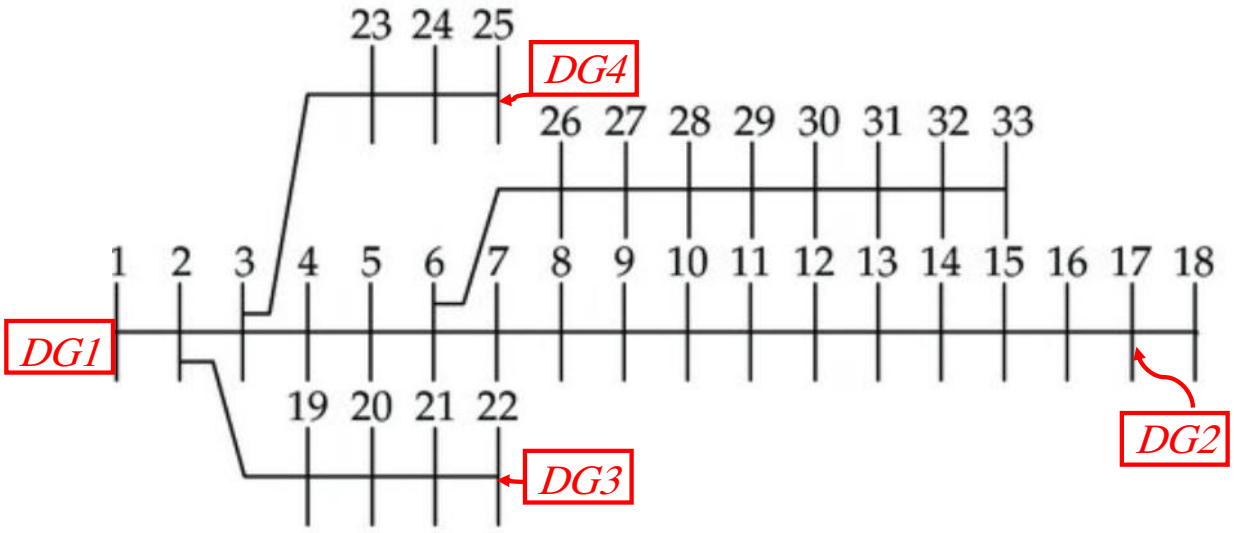

Fig. 1. Modified Islanded MG

Table I
DGs minimum and maximum capacity

DG No.	Minimum output power	Maximum output power
DG 1	20	100
DG 2	40	150
DG 3	50	150
DG 4	20	200

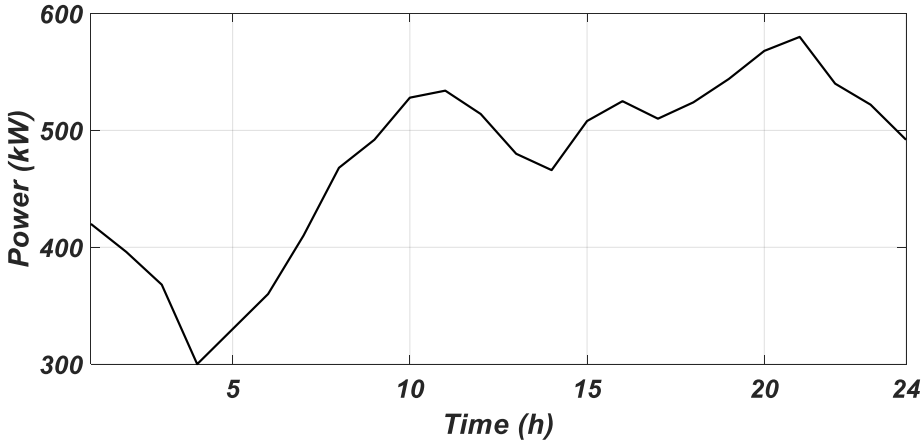

Fig. 2. Day-ahead forecasted values of load demand

The day-ahead forecasted values of the load demand is shown in Fig. 2. Fig 3 shows the output power of DGs. The cheapest unit is ON in the entire day. It should be noted that the price of the DG1 is less than other DGs. That means the power is based on the economic situation.

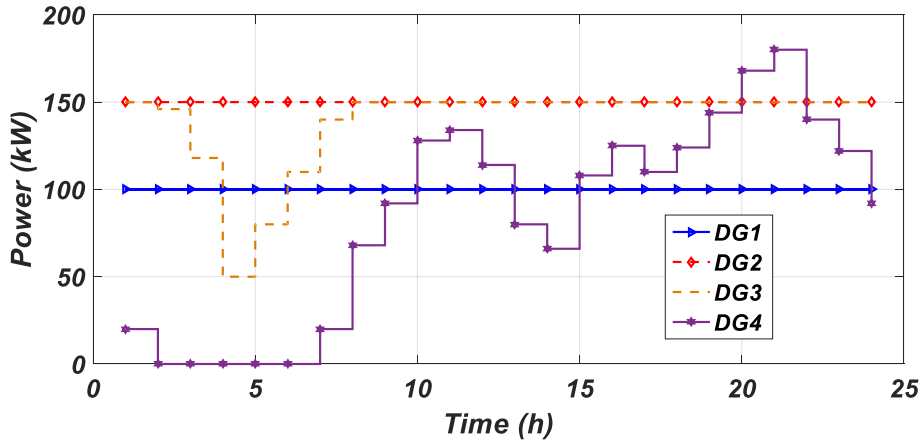

Fig. 3. DGs power in the self-supplied MG

The total operation cost of the MG grid in the self-supplied mode is presented in Table II. The cost is compared with the well-known algorithms. Results show the economic merit of

the proposed technique. Also, the convergence speed is very higher than well-known techniques.

Table II
Operation cost

	Operation cost ($)	Computational Time (second)
PSO	8436.3.7	11.6
GA	9635.25	12.4
Proposed method	7956.2	10.2

IV. CONCLUSION

In this paper a new evolutionary algorithm known as the multiverse evolutionary algorithm is proposed and adapted for the self-supplied MG. The results demonstrate the economic merit of the proposed method, compare to the well-known techniques such as PSO and GA algorithms. Also, the convergence speed of the proposed method is very higher than these techniques.

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