Region Search Optimization Algorithm for Economic Energy Management of Grid-Connected Mode Microgrid

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Abstract: Economic energy management of grid-connected microgrid has been widely investigated. However, due to the binary variables of the generation unit's status, the optimal result of the grid-connected microgrid is very hard. Thus, in this paper, the region search optimization algorithm (RSOA) is developed and adopted for the energy management of the grid-connected microgrid. The developed technique has higher convergence speed and accuracy, compared to the well-known heuristic techniques, such as genetic algorithm and particle swarm optimization. Results shows the effectiveness of the developed model.

Keywords: Grid-connected microgrid, economic energy management, industry microgrid,

I. INTRODUCTION

Small electricity network, known as the micorgrids, has been attracted lots of attentioans due to higher sustainability, resiliency, and reliability. In the microgrids (MGs) level of study, grid can be connected to the main grid and disconnected as well [1-10]. In the grid-connected mode, the microgrid can exchange energy with the upper level grid (main grid) [11-18]. That means, the microgrid can supply its demand not only by its own generation

units, but also using the main generator in the main grid [19-23]. In contrast, in the islanded mode, the microgrid is disconnected from the main grid [24-32]. That means, the require power of the microgrid network should me met using the microgrid generation units. Although in the grid connected mode there exist more stability from the power supply perspective, the energy management of the entire system is very challenging.

For solving the grid-connected microgrid, many heuristic and mathematical models have been used and investigated, such as particle swarm optimization (PSO) and genetic algorithm (GA). However, these algorithms trap to the local minimum by increasing the size of the network. That means, by increasing the complexity of the system, these algorithms are not able to find the optimal solution. Also, using the mathematical technique will not contribute to the optimal solution. To this end, this paper developed and adopted a new heuristic technique that can overcome the drawbacks of the previous methods. It is worth noting that the heuristic techniques have been widely used in many researches, in several fields so far [20-32].

II. MATHEMATICAL MODELLING OF CONNECTED MICROGRID

Grid-connected main objective is to minimize the generation cost of units, as

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

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

SU and SD: Startup and shutdown costs.

Please consider the following nomenclature for the rest of this paper.

UT, DT: Minimum up and down

$T_{(on)}$, $T_{(off)}$: Number of successive on and off hours

RU, RD: Ramp up and down of the generators.

Also, the grid-connected microgrid constraints are

$$P_{it,min} \leq P_{it} \leq P_{it,max} \tag{2}$$

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

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

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

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

This paper developed a new heuristic method known as the region search optimization algorithm for the grid-connected microgrid energy management, which is taken from [15]. Moreover, the mutation operator is adopted to increase the convergence speed of the algorithm.

III. SIMULATION RESULTS

To show the merit of the algorithm for the grid-connected mode microgrid, the IEEE 69 bus test system, including 4 DGs has been tested, as shown in Fig. 1.
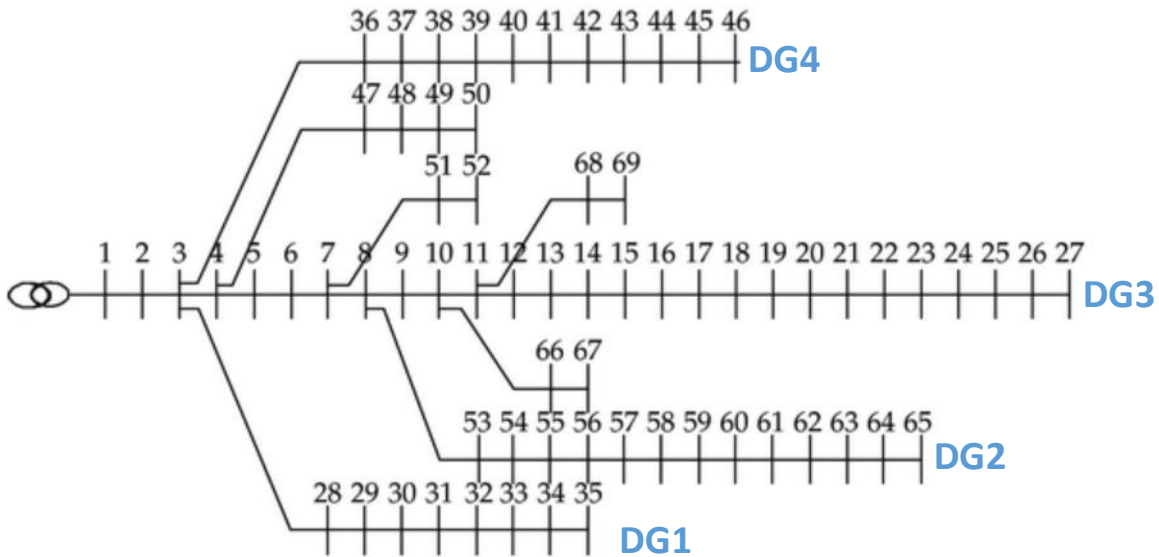

Fig. 1. IEEE 69 bus test system diagram

DGs feature are in Table I.

Table I
DGs features

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

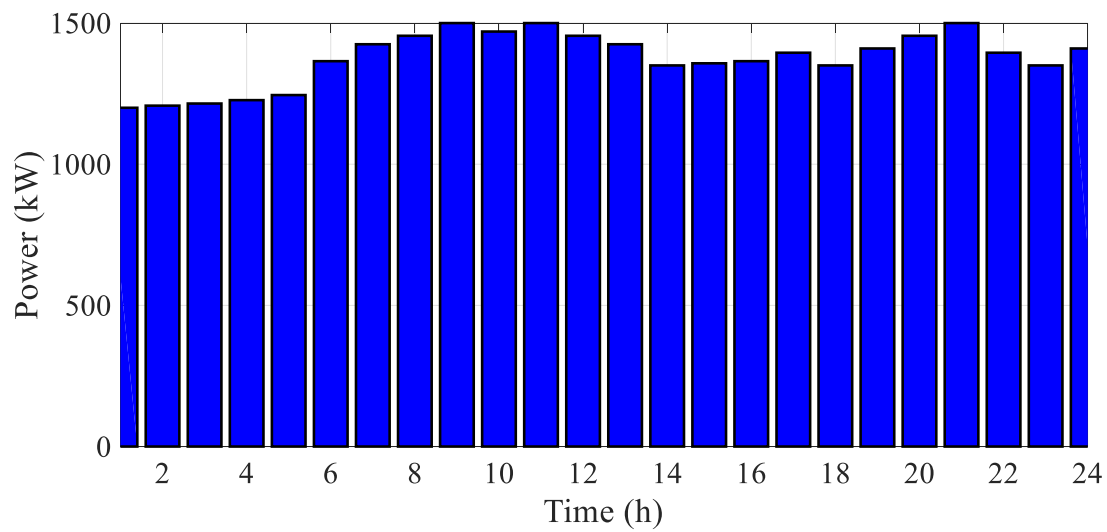Load demand of the network are presented in Fig. 2.

Fig. 2. Load demand of the network

DGs output power are mainly based on the economic perspective as shown in Fig. 4. The active DGs is the first DG where it has lower price.
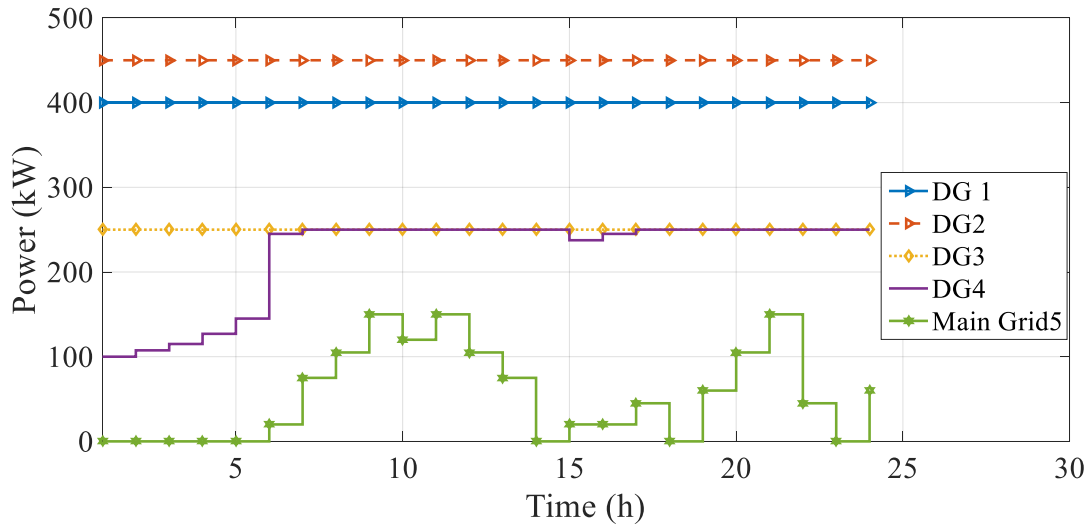
Fig. 3. Produced powers by DGs

Table II compare the operation cost and convergence speed of the algorithm. The results prove the effectiveness of the proposed model.

Table II

Cost of operation for several methods

	cost ($)	Convergence (s)
PSO	637335	11.1
GA	623437	9.9
Proposed method	512532	7.1

IV. CONCLUSION

Region search optimization algorithm is one of the powerful heuristics techniques that has been used in this paper for optimal energy management of the grid-connected MG. Results shows that compare to the PSO and GA, this method has higher convergence speed, which is one of the key points in grid-connected operation. In addition, it has lower operation cost for the microgrid operation compare to GA and PSO.

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