Islanded Microgrid Operation Based on the Chaotic Crow Search Algorithm

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Abstract: This paper investigates the optimal operation of the islanded microgrid. In order to find the optimal solution and also provide a fast response, a new heuristic method, which is known as the chaotic crow search optimization algorithm is developed. To show the merit of the model, it is tested on the IEEE 30 bus test network.

I. INTRODUCTION

MICROGRID is one of the most interesting research among the researchers with the past ten years, because of both economic and technical advantages [1-5]. Microgrid is a very small electricity grid that can produce power for the consumers within its network. That means the electricity power producers and consumers are inside each other. Hence, the less transmission line is required, that can lead to less expansion planning cost. Also, as there are beside each other, the reliability, voltage profile, and power quality of the network can increase a lot.

As mentioned above, microgrid has lots of advantages, but many problems with the microgrid are not solved completely yet. For instance, the protection and optimal operation have not been addressed completely yet. Therefore, this paper will investigate the optimal scheduling of islanded microgrid. The word islanded means the microgrid is disconnected

from the main grid. Also as mentioned, the dispatchable generators of the microgrid should meet the required load. Also, when we say the connected mode, means conventional power grids, where the microgrid is connecting to the main grid and can exchange power. It should be noted that in this paper, only the islanded operation of microgrid is investigated.

Islanded microgrid control is studied in [6]. Designing a DC/DC boost converter, which is applicable for microgrid operation is studied in [7]. Solving the microgrid operation by the heuristic algorithms such as CDOA, GA, PSO, TLABO, etc. is studied in many literatures such as [8-11]. Develop an effective control for microgrid operation is also studied in [12-15]. Investigating on adding the electric vehicles, superconductivity of the microgrid, and security of the microgrid has been studied in [16- 19]. This paper investigates the optimal operation of an islanded microgrid by adopting a new heuristic method known as chaotic crow search optimization algorithm [20].

II. Problem formulations

The proposed problem includes an objective function that tries to minimize the operation cost of the islanded microgrid and some constraints as follows:

A. Objective function

The objective function is defined as

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

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

B. Constraints

The proposed problem includes some constraints as follows:

The capacity of the generators as limited. That means at any time, the output power (*P*) of each DG should be within a limit as

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

The generators have a limitation on the ramp up and down as

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

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

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

The last but not least constraint is the minimum up and down limits that can be calculated as

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

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

where UT_i and DT_i are minimum up and down rates of the *i*th unit. Also, $T_{(on)}$ and $T_{(off)}$ denotes the number of successive on and off hours.

III. Chaotic Crow Search Algorithm

The Islanded microgrid is a mixed integer programming (MILP) problem. To solve this MILP problem, this paper developed a new heuristic method known as the chaotic crow search algorithm. This algorithm inspires from the crow search apparatus for hiding the food. More explanations of this algorithm is in [20]. Figure 1 shows the chaotic crow search algorithm flowchart. It should be noted that in recent years, the heuristic algorithm

has been attracted lots of attentions because of fast and accurate response [21-24]. These algorithms have been developed in many papers in different field of science.

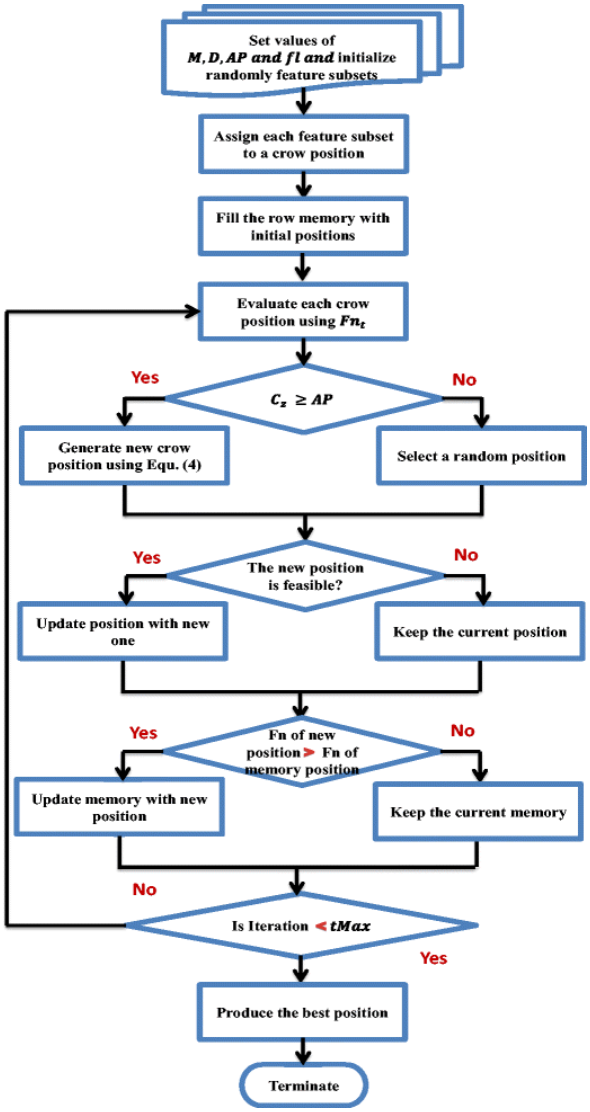

Fig. 1. Flowchart of the proposed method [20].

IV. RESULTS

In this section, a modified IEEE 30 bus test network is selected to test the merit of the proposed model. The network contains three generation units, as shown in Fig. 2. Also, the features of the units have been shown in Table I. The day-ahead load demand is shown in Fig. 3.

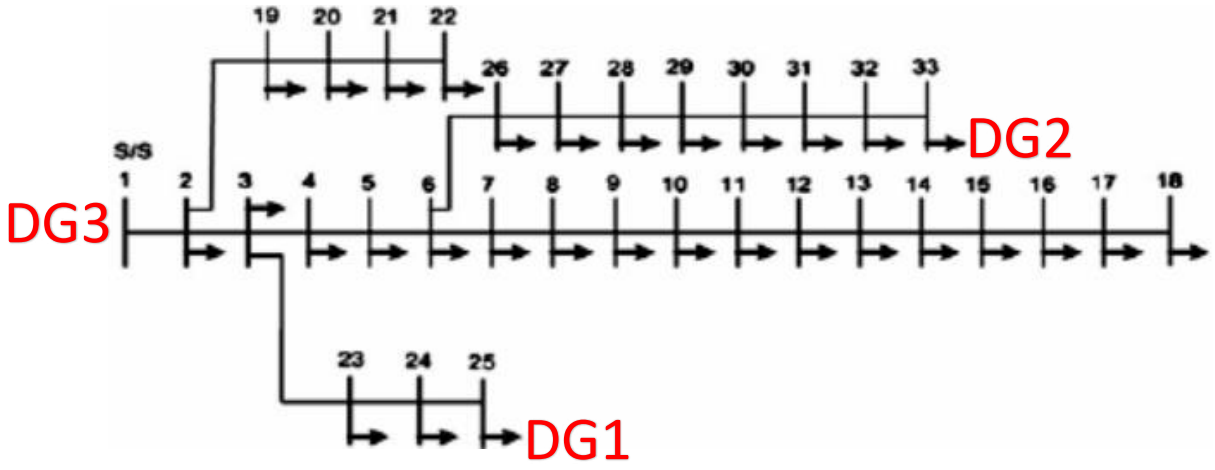

Fig. 2. Single line model

Table I
Features of Units

	Minimum output power	Maximum output power
Unit 1	20	100
Unit 2	40	50
Unit 3	1	25

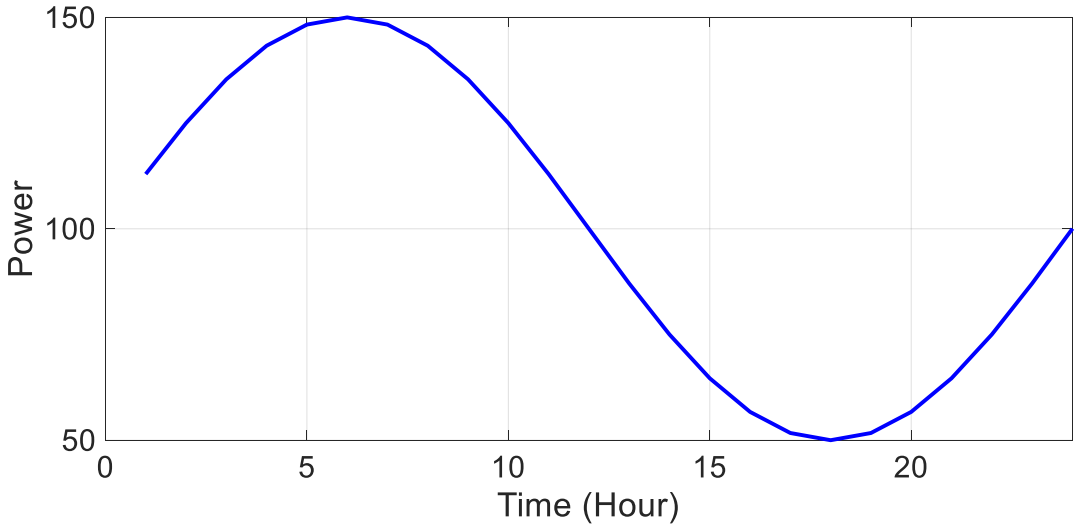

Fig. 3. Day-ahead load demand

Fig. 4 shows the output power of units. Based on this figure, the cheap unit has participated more than others that can lead to less operation cost.

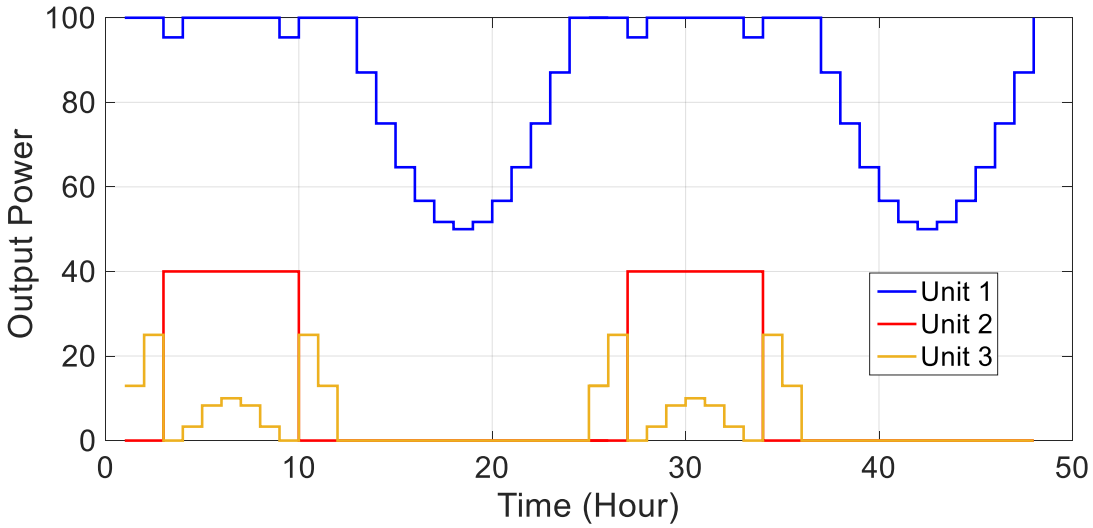

Fig. 4. The output power of Units

Table II shows the operation cost of the proposed method and it is compared with the particle swarm optimization (PSO) and genetic algorithm (GA) methods.

Table II
Operation cost

	Operation cost ($)	Computational Time (second)
PSO	5432.1	14.2
GA	5532.5	11.8
Proposed method	5334.2	9.2

V. Conclusion

This paper developed a new heuristic method for the optimal operation of the islanded microgrid. The results demonstrate the fast response and optimality of the proposed method. Also, based on the results, the status of this method is completely different from the well-known methods such as PSO, GA, and TLBO.

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