Economic Operation of Self-Sustained Microgrid Optimal Operation by Multiobjective Evolutionary Algorithm Based on Decomposition

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2019

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Abstract: This paper focuses on the optimal operation of the islanded microgrid. A novel heuristic method known as the Multiobjective Evolutionary Algorithm Based on Decomposition is presented to search for the optimal solution with a fast response. The efficiency of the method is tested on the IEEE 33 bus test network.

I. Introduction

In the recent decade, MICROGRID has gained growing interest among researchers due to its economic and technical advantages [1-5]. Microgrid is referred to a small electricity grid which produces power for the consumers that exist inside the network. In other words, electricity power producers and consumers are posited inside this small network. One of the main advantages of this system is the less transmission line required which consequently lowers the expansion planning cost. Moreover, the adjacency of the system's elements results in increase in reliability, voltage profile, and power quality of the network.

Despite so many advantages of microgrid, there are several problems with it that are not thoroughly solved such as the protection and optimal operation of the system. This paper addresses the optimal scheduling of islanded microgrid. A microgrid is said to be islanded when it is disconnected from the main grid. The load of dispatchable generators of the microgrid should not exceed the defined limit. Connected mode of a microgrid means that it can exchange power with conventional power grids, the grid that it is connected to. The investigation of this paper is narrowed down to only the islanded operation of microgrid.

Control of an Islanded microgrid is studied in [6]. Also, reference [7] studied design of a DC/DC boost converter that is implemented for microgrid operation. A few heuristic algorithm techniques such as CDOA, GA, PSO, TLABO, etc. are used to solve the microgrid operation, which are discussed in the literatures [8-11]. Moreover, references [12-15] have focused on development of an effective control for microgrid operation. References [16-19] have investigated addition of the electric vehicles, superconductivity of the microgrid, and security of the microgrid. It should be noted that different optimizing techniques, such as response surface methodology (RSM), the Taguchi-based methods, the fuzzy neural system (FNS), and the artificial intelligence (AI), are common methods for data analysis of different systems in a wide range of engineering applications, some of these technique are excellent for evaluation of complicated processes with uncertainty [20-27]. This paper presents a new heuristic method known as chaotic Multiobjective Evolutionary Algorithm Based on Decomposition search optimization algorithm for optimal operation of an islanded microgrid [28].

II. Problem formulations

The discussed problem tries to minimize the operation cost of the islanded microgrid by defining an objective function and applying several constraints to it.

A. Objective function

The objective function in this problem is as follows:

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

Where:

I is a binary variable that can be zero or one and determine the status of unit *i* at time *t.*

SU and *SD* are the startup and shutdown costs of the *i*th unit at time *t*.

B. Constraints

Several constraints are applied on the proposed optimization problem. Since the capacity of the generators as limited, the output power (*P*) of each DG should be within the following limit at ant single time.

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

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 ith unit.

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

It is worth noting that the proposed problem has been solved based on the multiobjective evolutionary algorithm based on decomposition. More detail regarding this algorithm can be found in [28]. It is worth noting that the heuristic methods have been widely used in the similar problem or any other field of science. However, they can be trapped in the local minimum. Hence, analytical methods are used instead of them [29-36].

III. Results

Figure 1 shows the single line diagram of the tested model, which is contains four distributed generators (DGs). The features of the DGs have been explained in Table 1. Also, day-ahead load demand has been demonstrated in figure 2.

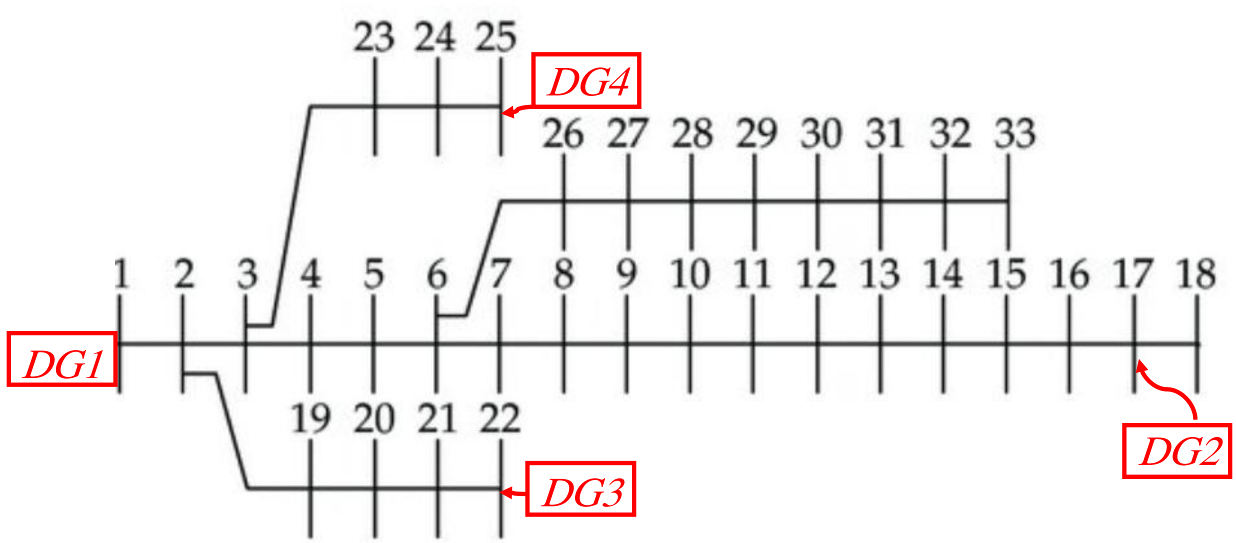

Fig. 1. Tested model single line model

Table I
Features of Units

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

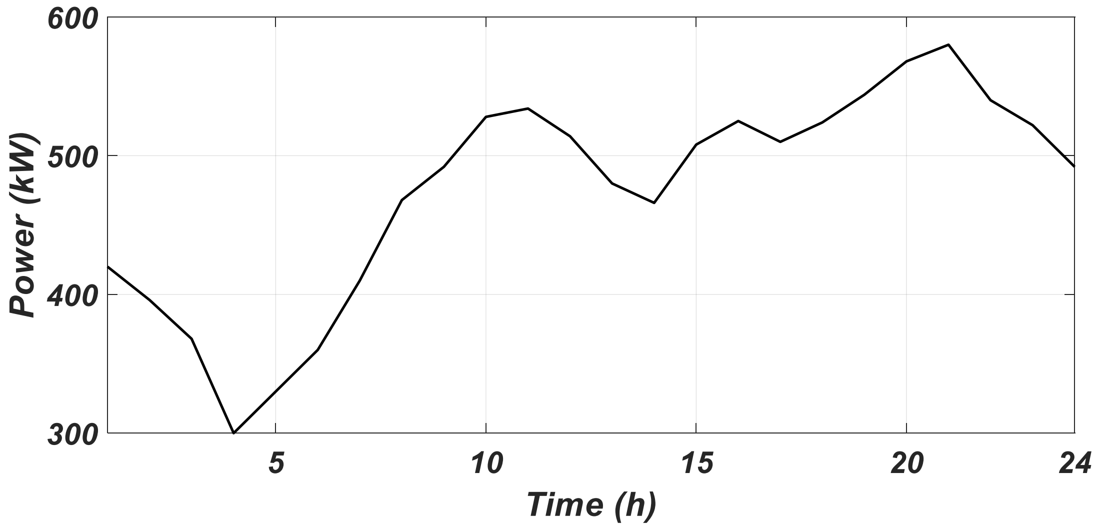

Fig. 2. Day-ahead load demand

Fig. 2 presents the DGs output power. The results demonstrate the effectiveness of the proposed method, as the output power of DGs are based on the economic consideration.

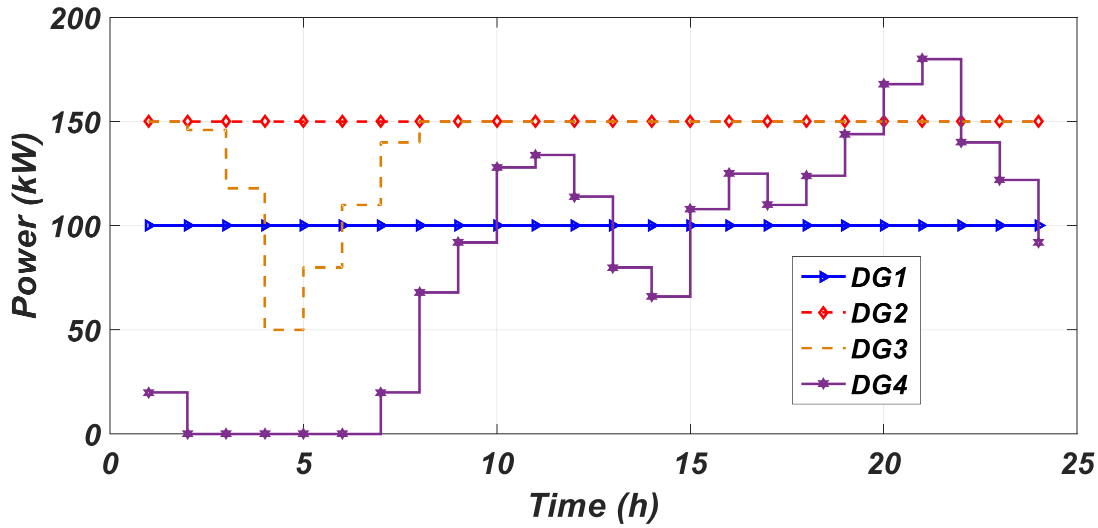

Fig. 4. The output power of Units

Total operation cost of the proposed method has been compared with the well-known algorithms such as particle swarm optimization (PSO) and genetic algorithm (GA) methods. The results are reported in Table II, that show the cost effectiveness of the proposed method.

Table II
Operation cost

	Operation cost ($)	Computational Time (second)
PSO	9648.7	15.6
GA	9234.5	14.4
Proposed method	7643.2	12.2

IV. Conclusion

In this paper, a new method has been developed for the economic operation of the self-sustained (islanded) microgrid. The results show the high speed, as well as the lower operation cost, compared to the well-known methods such as PSO and GA. It is worth noting that, the proposed method can easily implementable for practical grids.

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