Economic Self-Operation of Microgrids By Gravitational Emulation Local Search Algorithm

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Abstract: Islanded microgrid (MG) is a microgrid which is disconnected from the main network and therefore it is safe and has lead to one of the most important challenges in the power system operation. In the case of higher price in the market, the islanded MG offers a lower operational cost. On the other hand, the nonlinear attribute of optimal operation of the islanded MG has made difficulties in using such systems. To overcome this obstacle, a new heuristic method known as the Gravitational Emulation Local Search Algorithm (GELSA) is proposed in this paper in order to solve the problem. The efficiency of the technique is examined on a modified IEEE 30 bus test network.

I. Introduction

Microgrid (MG) is the accumulation of the load and distributed energy resources in which the generators satisfy the power demand requested inside the small network. This capability leads to significant economic and technical advantages [1-5]. A few advantages of these systems involve closeness to costumers, less transmission lien, higher reliability, higher resiliency, lower operation cost, etc. Despite all the advantages, an important challenge is optimal energy management of islanded MG which is a complicated problem. Among advanced methods of optimization like Taguchi, grey, grey-fuzzy, and grey-adaptive neuro fuzzy inference system–integrated approach [6-9]. This paper presents a new technique for optimal energy management of islanded MG. In this study, the small grid is disconnected from the main network and consequently, the generation units only provide the load demand of the small network. As a result, in this mode, power exchange with the main grid is blocked.

A number of researchers have implemented evolutionary algorithms, e.g., CDOA, GA, PSO, and TLABO to study energy management of islanded MG [8-11]. Moreover, some literature has widely studied efficient control of MG operation [12-15]. References [16-20] have investigated utilization of electric vehicles (EVs), MG superconductivity, and MG security. Function of an islanded MG is a nonlinear problem and seems hard to solve. Another important factor in solving nonlinear problems is the convergence speed. Therefore, in this paper a new method known as the gravitational emulation local search (GELS) algorithm is developed and presented in order to find a solution for nonlinear problem of optimization of MG systems [16-19].

II. MATHEMATICAL FORMULATIONS OF THE PROBLEM

A. Objective function

Objective function for this problem of minimizing the operational cost is defined as:

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

whsere:

I is Binary variable {0,1}

*SU,SD are s*tartup and shutdown costs

B. Constraints

The constraint imposed on this problem are the following items.

The limit on capacity of each generation unit is:

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

Also the limit on ramp up and down of each generation unit are:

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

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

where:

RU_i , RU_i are ramp up and ramp down of the *i*th unit

Finally, the limited up and down time of each generation unit is considered 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, DT_i are minimum up and down rates of the *i*th unit

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

III. Gravitational Emulation Local Search Algorithm

As mentioned, the proposed problem is a mixed-integer linear programming (MILP) problem, which is hard to solve by the mathematical models. Also, the optimal solution is not assuring by solving the problem by the mathematical approach. To this end, in the paper, a new evolutionary algorithm known as the gravitational emulation local search (GELS) a is adapted to solve the problem. More detail regarding this algorithm can be found in [20]. It should be noted that evolutionary methods are used widely in many fields because of the fast and precise response [21-23].

IV. Results

To show the economic merit of the proposed technique, the modified IEEE 30 bus test system is selected and tested, as shown in Fig. 1. The system has 3 distributed generators (DGs) as explained in Table I. Also, the 24-hours load demand is shown in Fig. 2.

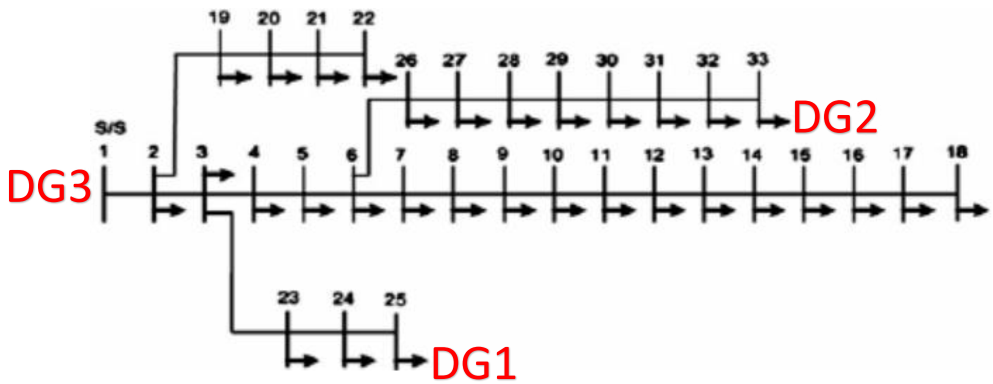

Fig. 1. Single line model

Table I
Features of Units

	Minimum output power	Maximum output power
Unit 1	20	80
Unit 2	20	50
Unit 3	1	25

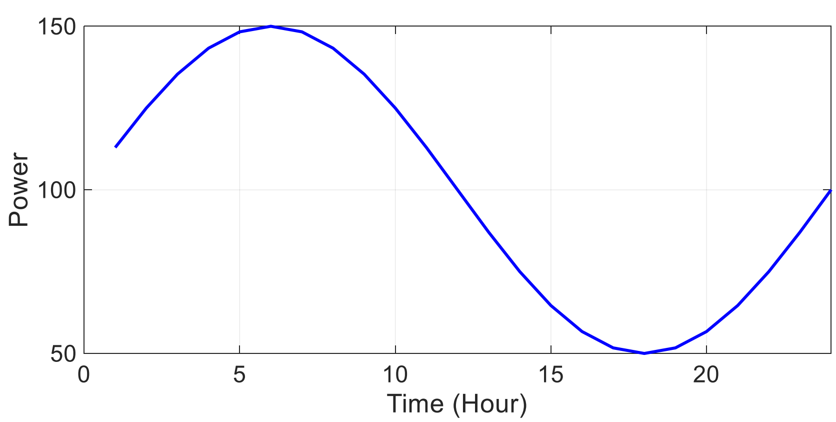

Fig. 2. 24-hour load demand

The DGs output is shown in Fig. 3, where the output of the DGs are based on their economic price. That means cheapest units are more active than others.

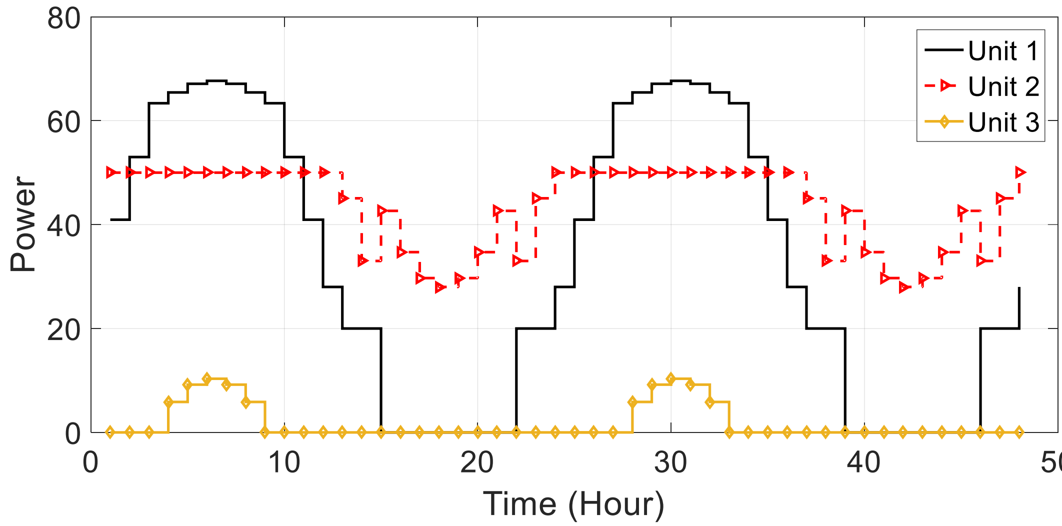

Fig. 3. The output power of Units

Table II shows the total operation cost of the proposed problem under difference algorithms. The proposed technique has higher speed and lower operation cost.

Table II
Operation cost

	Operation cost ($)	Computational Time (second)
PSO	5432.1	14.2
GA	5532.5	11.8
Proposed method	5114.7	8.7

V. Conclusion

In this paper a new heurist technique, known as the GELSA has been developed for solving MILP microgrid operation. The results have been compare with the PSO and GA. Results prove the higher speed of the proposed method. Also, from the economic perspective, the proposed method has lower operation cost. This method can be easily adaptable in the power industrial grids as it has a very high speed and accuracy.

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