Economic Operation of Islanded Microgrids Based on the Region Search Evolutionary Algorithm

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Abstract: In this paper a new evolutionary algorithm based on the region search evolutionary algorithm (RSEA) is developed for optimal energy management and operation of microgrids. Islanded microgrid operation is more crucial than the conventional distribution grids because of less dependency of the extremal (upstream) generation units. Thus, an effective economic operation of islanded microgrid need a strong algorithm to meet all constraint associated with the problem. The proposed developed RSEA technique is tested on the IEEE 33 bus test system. Results show the effectiveness of the RSEA technique, compared to the well-known evolutionary techniques.

Keywords: Islanded microgrid, heuristic technique, economic operation.

I. INTRODUCTION

In the recent years, Microgrid (MG) has been investigated widely due to economic and non-economic (technical) reasons, e.g., higher reliability and resiliency, higher efficiency, lower operation cost, etc. However, this benefits are associated with many drawbacks, e.g., control stability, economic operation, and protection that should be investigated before using the microgrid in the real world [1-12].

Microgrid economic operation is a mixed-integer linear programming problem due to the binary variable [13-16]. These binary variables are the status of the generation units that should be ON or OFF during the day-ahead operation. As the mixed-integer linear programming problem, it is hard to solve due to non-convexity and complexity of the problem.

Many researchers have been investigated for the economic operation of the microgrid, both mathematical and evolutionary techniques. It should be noted that the mathematical techniques are not able to find the optimal point of operation; however, the convergence speeds of them are fast. On the other hand, evolutionary techniques can find the optimal operation techniques; however, they convergence speeds are not as fast as mathematical techniques [17-21]. It should be noted that evolutionary techniques are widely used in many researches in many fields so far [22-30]. Hence, using them in power grid operation are highly recommended due to their advantages. For the microgrid operation some evolutionary algorithms, e.g., CDOA, GA, PSO, and TLABO are studied. Moreover, some literature has widely studied efficient scheduling of microgrid operation, considering renewable energies, electric vehicles, practical constraints, etc. In this paper, unlike the other researches, a new method known as the region search evolutionary algorithm (RSEA) is developed and presented in order to find a solution for nonlinear problem of optimization of MG systems.

II. Mathematical Model of the Problem

Islanded microgrid operation is an optimization problem, containing an objective function (1) and constraints (2)-(6). The objective function is to minimize the operational cost of the generation units within the network, as presented in (1). In this equation, *I* is

the binary variable {0,1} and *SU, SD* are startup and shutdown costs. Constraints of the problem are (2)-(6). The generation unit's limitations are presented in (2). Also, the ramp up and down limitations of the generation units. In this equations RU_i, RU_i are ramp up and ramp down of the *i*th unit. At the end, the limited up and down time of each generation unit are defined in (5) and (6). In these formulations is considered as UT_i, DT_i are minimum up and down rates of the *i*th unit and $T_{(on)}, T_{(off)}$ are number of successive on and off hours.

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

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

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

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

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

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

III. Gravitational Emulation Local Search Algorithm

As explained above, the islanded microgrid economic operation problem is a mixed-integer linear programming (MILP) problem, which is not easy to address using the mathematical models, since the optimal solution of the mathematical techniques are not guarantee. Therefore, in the paper, a new evolutionary algorithm which is known as the region search evolutionary algorithm (RSEA) is used to overcome the proposed problem. Regarding this technique, more detail algorithm can be achieved in [31].

IV. RESULTS

In this section, the effectiveness of the RSEA will be shown by examining of this technique on the microgrid operation and comparing with other techniques. Hence, IEEE 33 bus test system is examined and tested. Figure 1 shows the single line diagram of this network. The proposed network includes three distributed generators (DGs) as explained in Table I. Also, the day ahead demand is shown in figure 2.

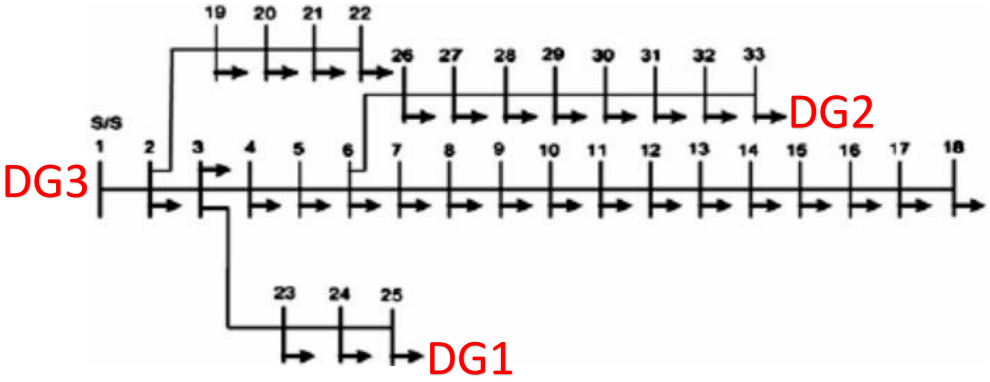

Fig. 1. Single line model

Table I

Features of Units

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

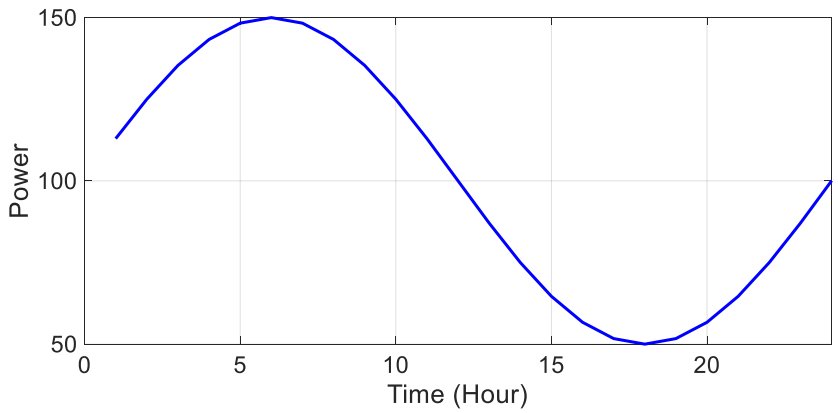

Fig. 2. 24-hour load demand

The output power of the DG using RSEA. As shown this technique is very powerful since cheapest units are more active than others.

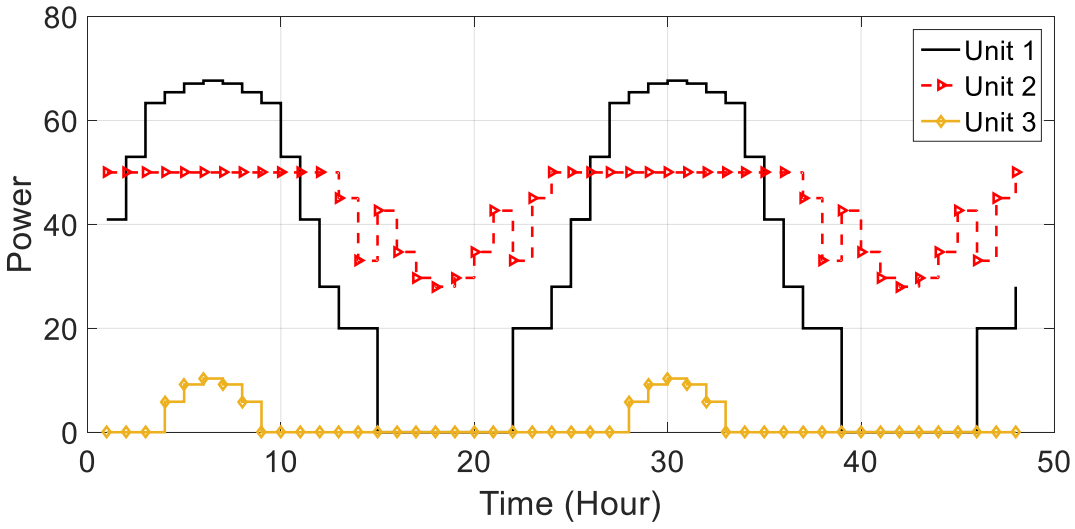

Fig. 3. The output power of Units

The total operation cost of considering several algorithms are shown Table II. Based on this table, the RSEA has higher speed and lower cost.

Table II

Operation cost

	Operation cost ($)	Computational Time (second)
PSO	5432.1	14.2
GA	5532.5	11.8
RSEA	5110.7	8.1

V. CONCLUSION

This paper proposed an evolutionary technique, known as the RSEA has been used for addressing MILP islanded microgrid economic scheduling. Results are also compared the PSO and GA. Results show the higher speed, as well as lower cost of the RSEA. This technique can be used in the power system operation because of its high speed and accuracy.

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