Microgrid Economic Operation Under Islanded Mode Using Charge System Search Algorithm

Tavaro, Mehdi and Noori, Ehsan and Khazei, Ehsan and Bardideh, Farhad

Electrical and Computer Engineering Department, Sazeh Sazan Power Company, Iran, Electrical and Computer Engineering Department, Sazeh Sazan Power Company, Iran, Electrical and Computer Engineering Department, Sazeh Sazan Power Company, Iran, Electrical and Computer Engineering Department, Sazeh Sazan Power Company, Iran

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Mehdi Tavaro, Ehsan Noori, Ehsan Khazaei, Farhad Bardideh
Electrical and Computer Engineering Department, Sazeh Sazan Power Company, Iran

Abstract: This paper proposes a new heuristic algorithm which is known as the charge system search algorithm (CSSA) for optimal power scheduling of islanded microgrid (MG). This technique is tested on the IEEE 33 bus test system. Also, to speed up the algorithm, a new mutation operator is designed. Results demonstrate the high efficiency of the proposed technique.

I. Introduction

Microgird (MG) is one of the important and critical tasks in modern power system operation as planning due to some important benefits associated with MG such as closeness to the consumers, higher reliability, higher resiliency, lower operation cost, less transmission line, lower power losses, etc [1-7]. However, the power management of the MG is very challenging. When the MG is in grid-connected mode, it can exchange energy with the main grid [7-12]. In this status, the main grid can help the MG. Hence, shortage of power is not a critical point [13-15]. However, in the islanded mode, the MG is dis-connected form the main utility. In this condition the distributed generators (DGs) within the MG grid should satisfy the load demand of the MG grid. In this status the power management is very important and critical for the grid [16]. To this end, in this paper, a powerful heuristic algorithm known as the charge system search algorithm is proposed to handle the

complexity of the problem. MG is a mixed-integer linear programming (MILP) problem [17]. Hence, using the heuristic algorithm can overcome the complexity of the system. Also, to increase the convergence speed of the algorithm, a common mutation operator has been used.

II. Problem formulations

MG problem has an objective function, given by

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

The main goal it operation cost minimization. Also, here,

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

SU,SD: Startup and shutdown costs of the *i*th unit at time *t*.

MG has some constraints and limitations, given by

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

Here:

P: Output power of DGs.

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

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

Here,

RU_i ,RU_i : Ramp up and ramp down rates of the *i*th DG

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

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

Here

UT_i , DT_i : Minimum up and down rates of the *i*th DG

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

As mentioned above, this paper used the charge system search algorithm which is a heuristic method. This method is very better than particle swarm optimization (PSO) and genetic algorithm (GA). More detail regarding this algorithm can be found in [18]. Also, a mutation operator based on [19] is designed for the proposed method.

III. RESULTS

The single line diagram, as well as the DGs features are presented in Figure 1 and Table I respectively.

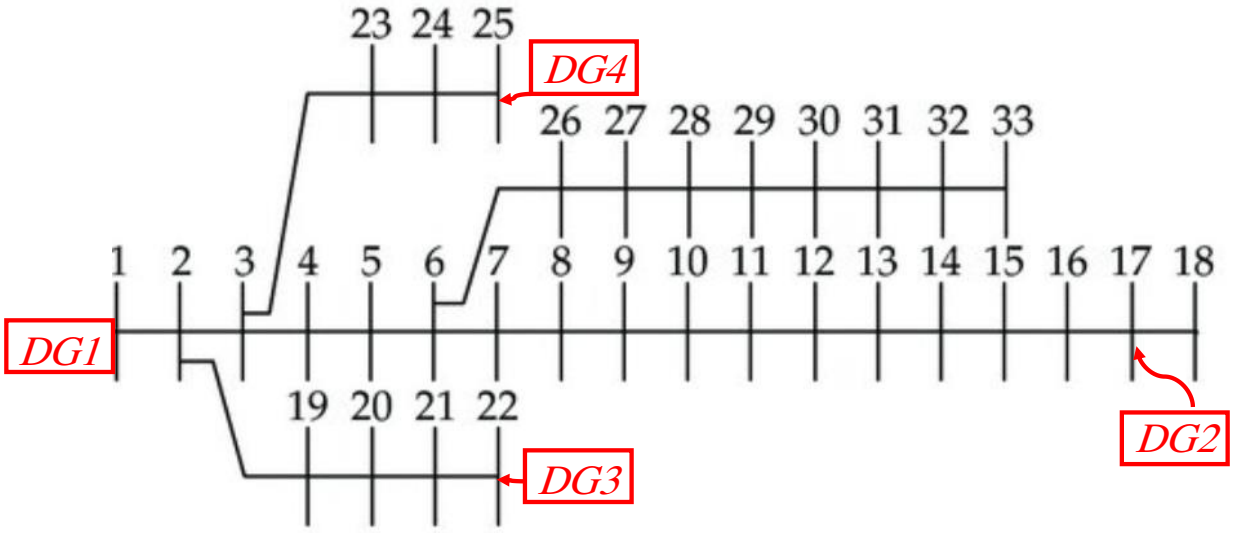

Fig. 1. Modified Islanded MG

Table I
DGs minimum and maximum capacity

DG No.	Minimum output power	Maximum output power
DG 1	20	100
DG 2	40	90
DG 3	1	40

DG 4	1	25

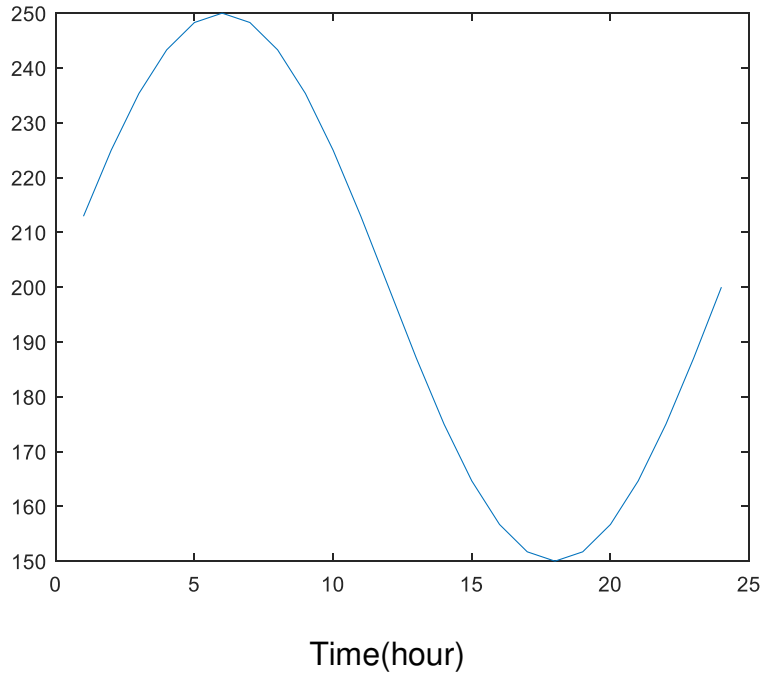

Fig. 2. Day-ahead forecasted values of load demand

The total power demand for 24 hours in depicted in Figure 2. Also, DGs power is depicted in Figure 3. As it can be seen the produced power of less expensive unit is higher than others.

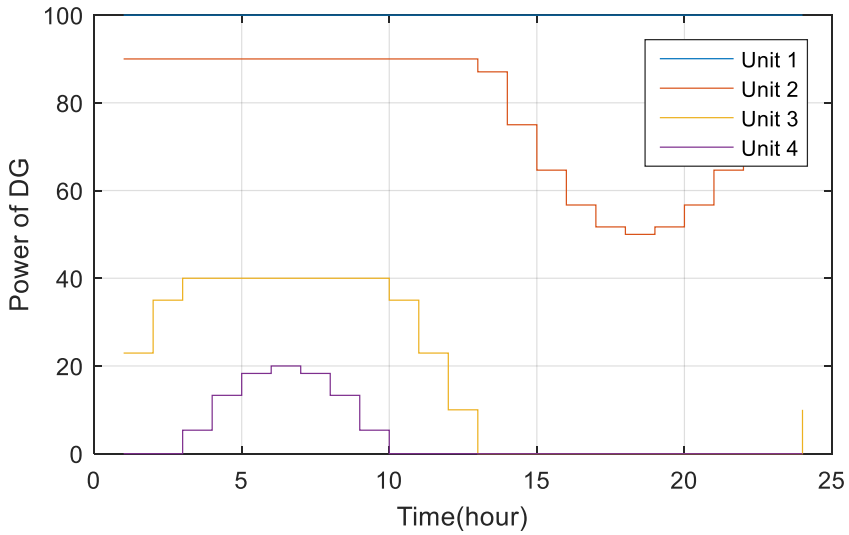

Fig. 3. DGs power in the self-supplied MG

Total operation cost and speed of the proposed technique is compared with PSO and GA. Based on this simulation results, the performance of the proposed method is very better than others, form both speed and cost views.

Table II
Operation cost

	Operation cost ($)	Computational Time (second)
PSO	8436.3.7	11.6
GA	9635.25	12.4
Proposed method	7956.2	10.2

IV. Conclusion

Charge system search algorithm is one of the powerful heuristic methods that has a high speed and performance compared to the well-known methods such as particle swarm optimization and genetic algorithm. In this research study, this method is used for power management of the islanded microgrids. This method is tested on the IEEE 33 bus test system. Results prove that using the proposed technique can lead to lower operation cost and higher convergence speed.

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