Optimal Operation of Islanded Microgrid Operation Based on the JAYA Optimization Algorithm

Khazaei, Ehsan and Jamaledini, Ashkan

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

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Ehsan Khazaei, Ashkan Jamaledini

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

Abstract: Islanded microgrid (MG) is one of the most important challenges in the power system operation as the network can be safe and disconnected from the conjected area. Also, in the case that the market price is high, the islanded MG can have a lower operational cost by islanding from the main grid. However, optimal operation of the islanded MG is very challenging as the MG is a nonlinear problem. Hence, this paper proposed a new heuristic method known as the JAYA optimization algorithm to solve the problem. Finally, the proposed model is examined on a modified IEEE 30 bus test network to show the merit of the model.

I. Introduction

SUMMATION of the load and distributed energy resources known as the microgrid (MG) where the generators within a small network should satisfy the demand. This advantages, can lead to some benefits from both economic and technical perspectives [1-5]. MG has some importance advantages such as closeness to costumers, less transmission lien, higher reliability, higher resiliency, lower operation cost, etc. However, optimal energy management of islanded MG is very complicated. Consequently, this research proposed a new approach for optimal energy management of islanded MG. That means the small grid is disconnected from the main utility, therefore, the generation units should satisfy the load demand of the small network. Also, in the islanded mode, the MG cannot exchange power with the main grid.

Energy management control of islanded MG is studied in [6], and also a new DC/DC boost converter is developed for islanded MG operation in [7]. Addressing the energy management of islanded MG using evolutionary algorithms, e.g., CDOA, GA, PSO, and TLABO has been investigated in many set of literatures [8-11]. Also, efficient control of MG operation is widely investigated in [12-15]. Utilizing electric vehicles (EVs), MG superconductivity, and MG security are also investigated in [16- 20]. As mentioned, the islanded MG is a nonlinear problem which is hard to solve. Also, the convergence speed is important as well. Therefore, this paper developed a new algorithm which is known as the JAYA optimization algorithm to overcome the complexity of the problem [10].

II. Mathematical formulations of the problem

A. Objective function

The main objective is to minimize the operational cost as

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

I: Binary variable {0,1}

SU,SD: Startup and shutdown costs

B. Constraints

The proposed problem includes some constraints as follows:

Each generation unit has a limited capacity as

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

Each generation unit has a limited ramp up and down as

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

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

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

Each generation unit has a limited up and down time as

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

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

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

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

III. JAYA ALGORITHM

Islanded MG is a nonlinear optimization problem, which is because of the quadratic objective function (variable times variable). To handle the nonlinearity of the problem, this paper employed the JAYA optimization algorithm [10]. Further explanations of JAYA algorithm are clarified in [10]. General, evolutionary techniques are studied a lot in power system problems because of the fast and precise response [21-24].

IV. RESULTS

The IEEE 30 bus test system is tested to prove the merit of the proposed model. However, this model is modified as shown in Fig. 1. Also, the features of the units have been shown in Table I. The day-ahead load demand is shown in Fig. 2.

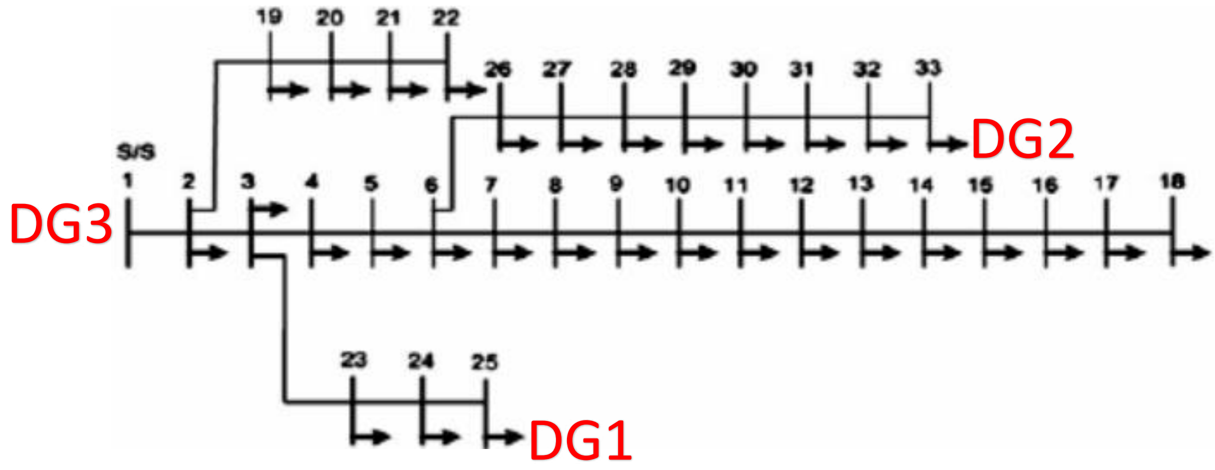

Fig. 1. Single line model

Table I
Features of Units

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

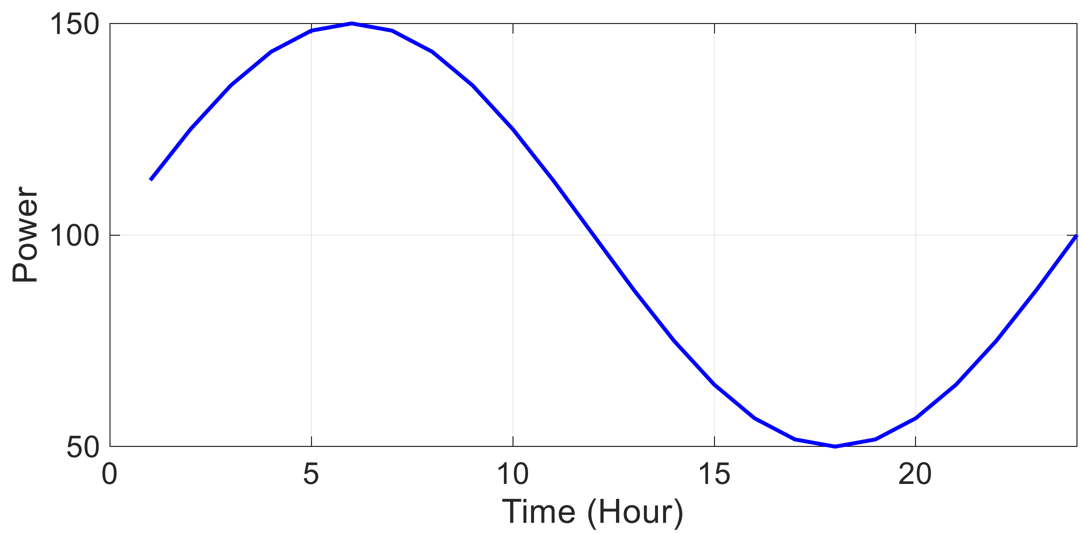

Fig. 2. Day-ahead (next 24-hour) load demand

The output powers of units have been shown in Fig. 3. As you can see, the cheapest unit is more participated than others; that means economic consideration.

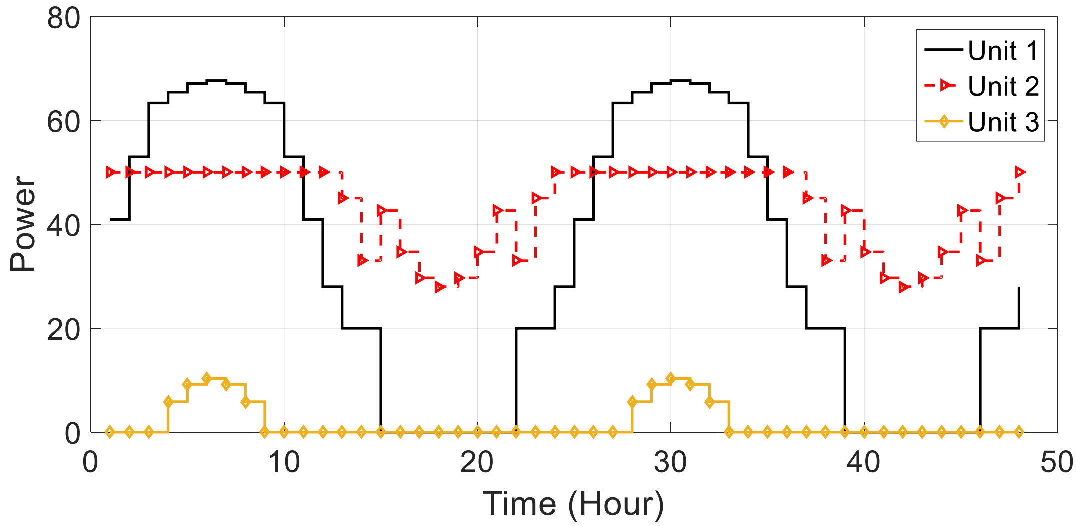

Fig. 3. The output power of Units

The operation cost of the proposed method and it is compared with other well-known models are presented in Table II.

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

A new heuristic method is developed in this paper for the energy management of islanded MG. The results show the fast response and lower operational cost of the proposed method. Furthermore, 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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