Solving the Grid-Connected Microgrid Operation by JAYA Algorithm

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Abstract: This paper aims to investigate the optimal operation of grid-connected microgrids (MG). In the grid-connected mode, the MG can connect to the main utility and also can exchange energy with the main grid. This potential can lead to higher reliability and less operation cost. In order to show the effectiveness of the proposed model, it is tested on a modified IEEE 33 bus test system.

Keywords: Microgrid, Jaya algorithm, Optimization, Grid-connected operation

I. Introduction

MICROGRID is small electric grid that the distributed generators are close to the consumers [1-5]. This closeness to the consumers can bring more benefits for the grid such as technical and economic advantages. The main reasons is less transmission line, higher reliability, higher resiliency, and higher power quality [6-7].

There exist lots of advantages in grid-connected MGs; however, the protection and operation are not investigated well yet. This paper addressed one of these challenges, which is energy management of the grid-connected microgrid. Islanded and grid-connected operation of MG are investigated in [6], and also developed a DC/DC boost converter for the grid-connected MG [7]. MG operation in the grid-connected mode is addressed by several heuristic methods, like CDOA, GA, and PSO [8-11]. The control of grid-connected and islanded MG is also addressed in [12-15]. Considering the electric vehicles (EVs) in MGs operation have been investigated [16-20]. MG is a nonlinear optimization problem. Hence, in this paper, a new evolutionary algorithm is developed which is known as the JAYA algorithm [10].

II. PROBLEM FORMULATIONS

A. Objective function

The objective is

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

J: Binary variable {0 ,1}

SU,*SD:* Startup and shutdown costs

UT,DT: Minimum up and down

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

RU,RD: Ramp up and down of units.

B. Constraints

- Each unit should be work within a limit as

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

- Each unit has a ramp up and down as

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

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

- Each unit has a minimum up and down as

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

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

III. JAYA Optimization Algorithm

In above, we mentioned that the MG is a nonlinear problem due to the quadratic function in the objective function. This can lead to complex problem. To overcome the complexity, this paper developed the JAYA optimization algorithm [10]. More explanation of JAYA algorithm is explained in [10]. Overall, heuristic methods are attracted to many considerations because of the fast and precise response [21-24].

IV. Results

A modified IEEE 30 bus test network is selected to show the effectiveness of the model. The single line of this model is shown in Fig. 1. Table I shows the characteristics of the units. The load demand for day-ahead is shown in Fig. 2.

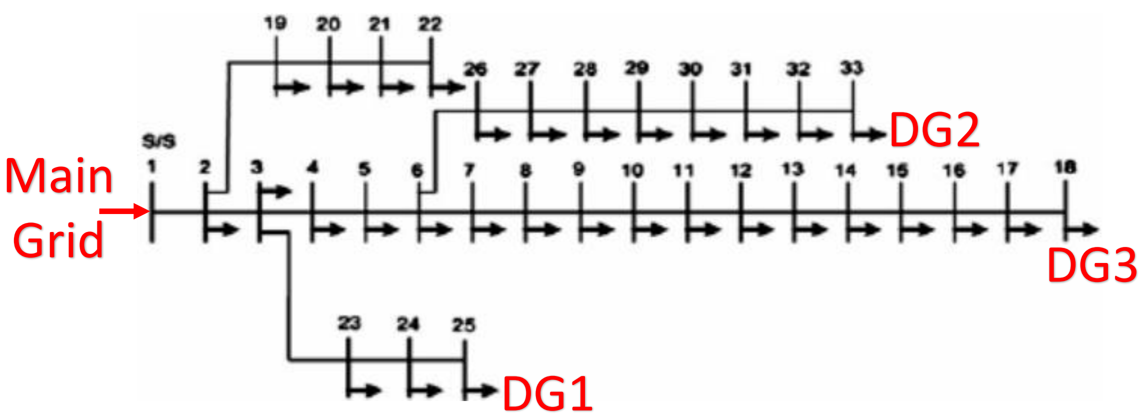

Fig. 1. Single line of the modified IEEE 30.

Table I
unit's features

	Minimum output power	Maximum output power
Unit 1 at bus 25	20	80
Unit 2 at bus 33	20	50
Unit 3 at bus 18	1	25

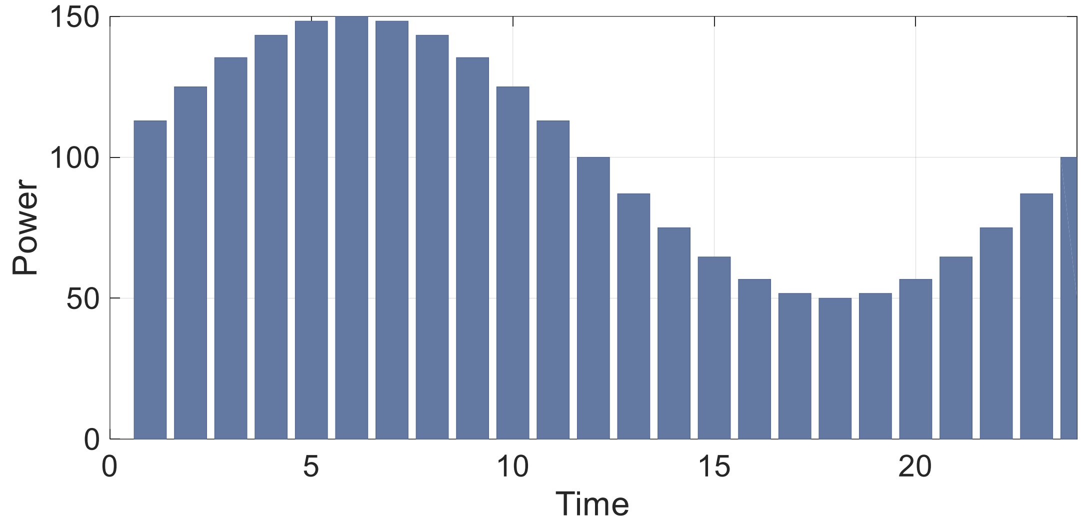

Fig. 2. Load demand for day-ahead

The output power of units is demonstrated in Fig. 3. According to the figure, the cheapest unit (unit 1) is more participated than other units; that the decision only is based on the economic.

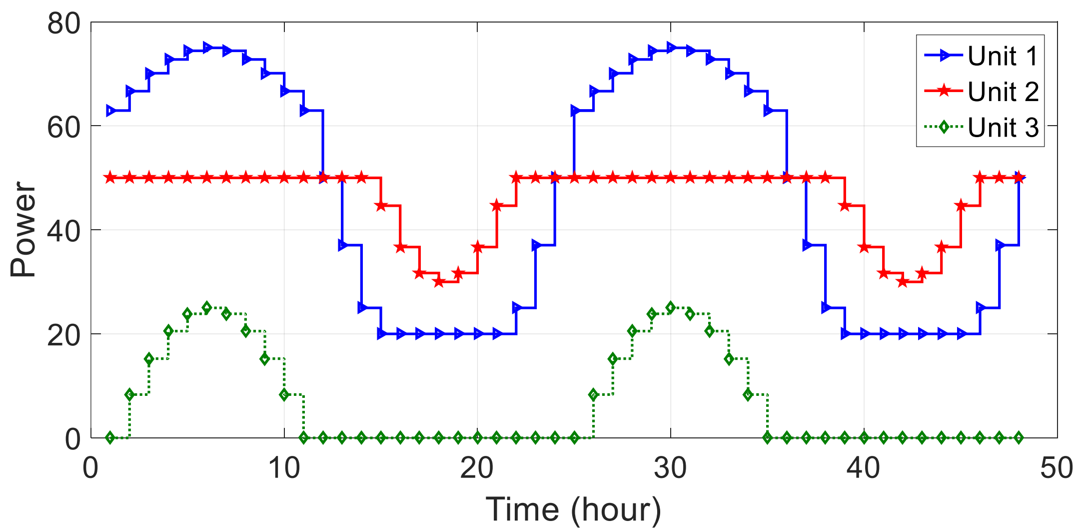

Fig. 3. Units output power

Cost comparison among different famous methods are studied in Table II.

Table II

Cost of operation for different methods

	Operation cost ($)	Computational Time (second)
PSO	4942.1	17.1
GA	4839.5	14.9
Proposed method	4132.2	11.9

V. CONCLUSION

In this paper, the JAYA algorithm is developed for energy management of grid-connected MG. In the grid connected mode, the MG can exchange power with the main grid. The results demonstrate the effectiveness of the proposed method, for both convergence speed and also operational cost. This method has a merit with other well-known methods such as PSO and GA.

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