Solving the Economic Scheduling of Grid-Connected Microgrid Based on the Strength Pareto Approach

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Abstract: This paper focuses on the operation of a microgrd which is connected to the main grid and can exchange power with it. To do so, the problem is modeled using mixed-integer linear programming (MILP). In the next step, an evolutionary algorithm known as Strength Perto Algorithm (SPA) is utilized to solve the model. In the end, the performance accuracy of the method is tested on a modified IEEE 69 bus test system.

Keywords: Microgrid, Distribution Grids, Optimization, Economic Scheduling

I. INTRODUCTION

Microgrid is refered to an aggregation of loads and distributed energy systems in a small network that is close to the consumers [1-5]. The mentioned systems have shown outstanding from several aspects like technical and economic. Closeness to the consumers, less transmission line, higher reliability, higher resiliency, and higher power quality are among several reasons why the system has gained interest [6-7].

Despite microgrid's significant benefits, there are still issues and challenges regarding the protection and operation which are not completely dissolved. In this paper, optimal operation of the grid-connected operation of the microgrid is investigated. A few reserachers have investigated Islanded and grid-connected operation of microgrid [6]. Moreover, some investigators have designed a DC/DC boost converter for the grid-connected operation of the microgrid [7]. In addition, several heuristic methods like CDOA, GA, and PSO are utilized to solve the model of a microgrid in the grid-connected mode [8-11]. References [12-15] have focused on control of grid-connected and islanded microgrid. Also, addition of the electric vehicles and the security of the microgrid is studied in [16- 19] in detail. In this study, Strength Perto Algorithm (SPA) is utilized to analyze the effective operation of the grid-connected microgrid [20-22].

II. Mathematical formulations

This optimization problem contains objective function and constraints.

A. Objective function

Objective function is defined as:

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

In which:

I is a binary variable (0 or 1) that controls the status of unit *i* at time *t.*

SU and *SD* are the startup and shutdown costs.

In this paper, the following nomenclature is used:

UT and DT are minimum up and down

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

RU and *RD* are the ramp up and down of the generators.

B. Constraints

There are several constraints in this problem that must be considered in the optimization model.

1. Capacity of the generators

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

2. Ramp up and down of the generators

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

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

3. Minimum up and down of the generators

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

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

III. TEACHING LEARNING BASED OPTIMIZATION ALGORITHM

The proposed problem belongs to the mixed integer linear programming problems, due to binary variables, e.g., generation unit's status. Hence, solving the problem is hard and the optimal solution is not assuring. To this end, paper utilized the Strength Perto Algorithm (SPA) to address the problem. More detail regarding the SPA can be found in [20]. Overall, heuristic methods are used in many researches, in different sciences, such as electrical, mechanical, signal processing, economics, oceanography, civil, etc. [21-32]. These methods have some significant advantages such as closeness to the optimal solution as [33-37].

IV. RESULTS

The proposed problem is tested on the IEEE 69 bus test system as shown in Fig. 1. The grid is connected to the main grid from bus 1 and can exchange power with the main grid.

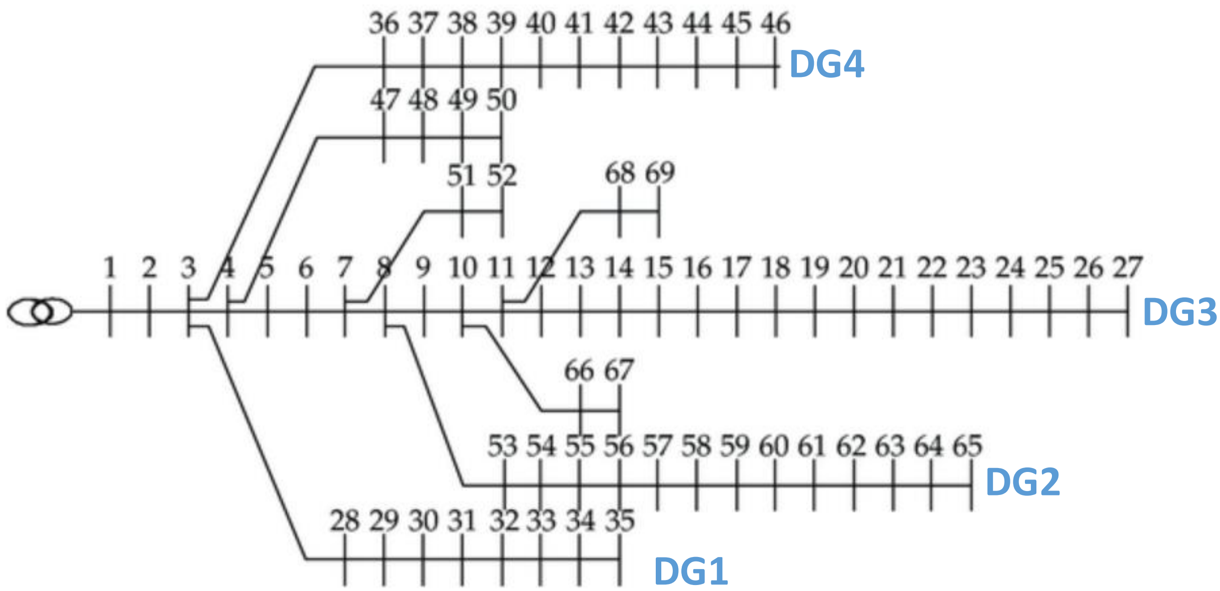

Fig. 1. IEEE 69 single diagram

The features of the DGs are presented in Table I.

Table I
DGs features

	Minimum output power	Maximum output power
DG1	20	400
DG2	40	450
DG3	10	250
DG4	10	250

The day ahead load demand is depicted in Fig. 2.

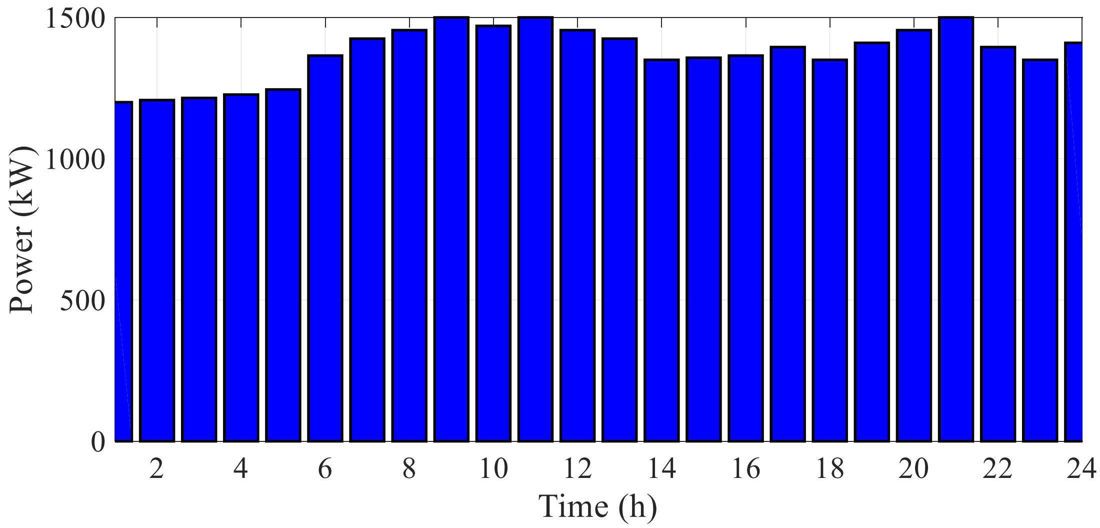

Fig. 2. Microgrid required day-ahead demand

Figure 3 shows the output of the DGs for the next 24 hours. The results prove the economic aspect of the problem, that can prove the high performance of the proposed technique. Indeed, DGs are ON so that the cost is minimized.

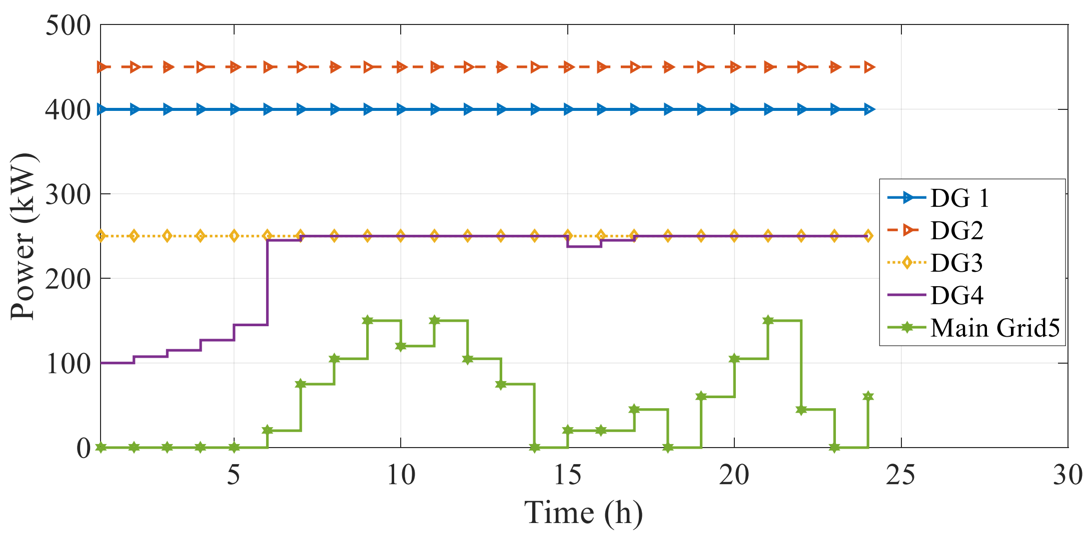

Fig. 3. DGs output power

Proposed problem is compared with particle swarm optimization (PSO) and genetic algorithm (GA) from the cost perspective in Table II. Results shows the high performance of the proposed technique. Also, the time of the convergence is very fasted than others.

Table II

Cost of operation for several methods

	cost ($)	Convergence (s)
PSO	637335	11.1
GA	623437	9.9
Proposed method	618322	6.2

V. CONCLUSION

This paper developed the PSA for the microgrid operation in grid-connected mode. The results show the economic merit of the model. Also, the convergence speed is very higher than the PSO and GA. The model is applicable for real-time applications as well.

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