The New Opportunity for Carrying Out a Dynamic Economic Dispatch using the Latest Evolutionary Computation Method

A. N. Afandi

Abstract*—Practically, a power system is operated by combined various types of generating units for determining a committed power schedule to meet load demand changes at all period times of the operation in order to reach the most economical operation. The committed power schedule of generating units is obtained by allocating power outputs based on the given load demand at a certain period time for minimizing the total cost considered some constraints. The total cost changes of operation are expressed by dynamic economic dispatch (DED) problems with considering load demand changes for each period time of the operation. In this paper, the harvest season artificial bee colony (HSABC) algorithm is used to solve the DED problem for 24 hours of operating times using IEEE-30 bus system. Simulation results show that the best solution of the problem is obtained by HSABC within the shortest iteration step. The computations used load demand changes for all period times are quick and smooth with stable characteristics of convergences. The DED problem is solved using HSABC in different convergence speeds, power outputs and total operating costs for 24 hours.

***Index Terms*—dispatch, dynamic, economic, HSABC, power.**

I. INTRODUCTION

Practically, a power system is constructed using interconnected structures for feeding electric energy from generator sites to some areas of the load demand. This main system is composed by generation systems, transmission systems, and distribution systems. One of purposes for this strategy is to reduce the total technical operating cost through the combination various types of power plants. An operating cost reduction is determined by sharing amount of the total power for each generation station due to a total load demand, which is expressed by an economic load dispatch (ELD) for minimizing the total cost. Specifically, ELD's primary objective is to schedule the committed generating unit outputs at a minimum total cost under some operational constraints [1], [2], [3]. Since the public awareness of the environmental protection have been increased to reduce atmospheric emissions, the ELD considers pollutant emissions in the air from combustions of fossil fuels at thermal power plants [4]. These generating stations release several contaminants, such as sulphur oxides, nitrogen oxides and carbon dioxide into the atmosphere. In additional, the Clean Air Act Amendments of 1990 have forced the power system operation to modify the operational strategies of the thermal power plants considered an emission dispatch (EmD) for reducing pollutants [5].

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By considering an EmD, the ELD problem has become a crucial task to optimize the total fuel cost with reducing pollutants for scheduling the generating unit outputs [6]. The ELD and EmD are transformed into single objective function as a combined economic and emission dispatch (CEED). Presently, many previous works have been successfully applied to solve the CEED problem [5], [7], [8], [9], [10], [11]. Concerning in the total cost of CEED problems, the power system is operated in a minimum cost by allocating power outputs of all committed generating units for all period times of the operation. Regarding in the period time of the operation, generating units commonly serve the given load demand over a certain period of the period time. Operationally, load demands are fluctuated from present hour to next hour during the operation. These conditions are associated with schedulled powers of generating units to meet the total load demand at every hour which are related to the various technical cost of generating unit operations. By considering the period time of the operation, the ELD become a dynamic problem because of load demand changes for every hour and it becomes an important theme to decide generation sites based on the minimum operating cost of the CEED. To meet these situations, the problem is accomodated as a dynamic economic disptach (DED) with considering load demand changes under operational constraints. In the DED, the load demand changes affect to the generated power of generating units for every hour. Power outputs are produced by considering ramp limits of each power stations to meet load demand changes. These limitations allow generation sites to supply load demands in permitted power changes of generators during the operation for every step of time periods. Presently, the DED is one of the main issues of the real time power system during 24 hour operations [12], [13], [14]. Many studies have been reported in literatures for solving DED problems using evolutionary methods. These methods search solutions of the DED using optimization techniques. Evolutionary methods are frequently used to bring out the DED problems, for instance, robust heuristic method, artificial immune system, neural network, particle swarm optimization, artificial bee colony algorithm (ABC) [14], [15], [16], [17], [18]. The ABC is a novel type of the evolutionary method and this algorithm is composed to mimic the foraging behavior of honeybees in nature [19]. Since the ABC was introduced in 2005, many previous works had been developed to improve its performances in various aspects, for examples smart flight ABC, multiple onlookers ABC, improved ABC [20], [21], [22]. According to previous works are known that the ABC's developmens have better results in abilities of the getting out of a local minimum and finding a global minimum. Besides, the ABC is also better in term of convergence speeds, efficiently used for multi

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variables and multimodal function optimizations. The variants of ABC are also easy to implement and capable of handling complex optimizations. Presently, the harvest season artificial bee colony (HSABC) algorithm has been introduced as the newest intelligent computation. This algorithm is composed by multiple food sources (MFS) for representing many flowers in the harvest season area and it is presented in 2013 [23]. As the novel evolutionary method, this paper presents an application of the HSABC for searching solutions of the DED problem. To perform the HSABC, IEEE-30 bus is addopted as a sample system and it is used to simulate the HSABC for obtaining the best solutions under several operational constraints.

II. Dynamic Economic Dispatch

The ELD has an objective for scheduling generating unit outputs by a minimizing total cost under technical constraints [2], [7], [8], [10]. Application of constraints in the ELD is used to pose a desired solution in the feasible space for a minimum cost. Presently, various pollutants from burning of fossil fuels are considered in the thermal power plants operation as limitations of the ELD [5], [9], [10]. By reducing pollutant emissions during minimizing the total cost, the CEED is composed from ELD and EmD problems with including a penalty factor and a compromised factor. A penalty factor shows the rate coefficient of each generating unit at its maximum output for the given load demand. A compromised factor shows the contribution of ELD and EmD in the CEED's computation. In general, the CEED problem is expressed by single objective function for optimizing the total cost. By considering a period time of the operation, the CEED is transformed into DED with considering load demand changes during operation. The DED is an extension of classical ELD problem for determining the optimum schedule of generating units at a certain period of the time that minimizes the total production cost while satisfied equality and inequality constraints in order to reach the most economical operating cost. Practically for convenience in solving the DED, the operating range of all online generating units is restricted by ramp rate limits in order to allow the scheduled power changes in the ranges of the generating unit operation [12], [13], [14], [15], [17]. Ramp limits are managed to control the power resources since the power transaction have used a standardized rectangular shape of starting and stopping productions on every hour during all period times of the operation [17]. These limitations are also used to maintain a mechanical effect in the rotor system for producing power outputs of generating units on the load demand changes. By considering ramp limits, the generating units are operated in the allowed ranges of power changes at a certain period of times to keep the life of the rotor [14]. The DED cannot be solved for a single value of the load demand since the ramp limits are involved as the operational constraints. For performing DED problems over all time intervals, DED's formula is computed by using equation (4). This expression is composed by ELD and EmD as given in equation (1) and equation (2). For obtaining the minimum solution, the DED can be executed by allowing several constraints, those are, an equality power of the load demand and generating units, power load flows with embedding losses for the lines, capacity limits of powers, each voltage at each bus, power transfer capability limits, and ramp limits. By mathematical functions, the DED's problem and its limitations for these works are presented as follows:

$$\sum_{t=1}^{T} FC_{total}^{t} = \sum_{t=1}^{T}\sum_{i=1}^{ng}\left(c_i + b_i . P_i^t + a_i (P_i^t)^2\right), \quad (1)$$

$$\sum_{t=1}^{T} EM_{total}^{t} = \sum_{t=1}^{T}\sum_{i=1}^{ng}\left(\gamma_i + \beta_i . P_i^t + \alpha_i (P_i^t)^2\right), \quad (2)$$

$$\sum_{t=1}^{T} \Phi_{total}^{t} = w.\left(\sum_{t=1}^{T} FC_{total}^{t}\right) + (1-w).\left(\sum_{t=1}^{T} h^t . EM_{total}^{t}\right), \quad (3)$$

$$\text{Minimize DED} = \text{minimize} \sum_{t=1}^{T} \Phi_{total}^{t}, \quad (4)$$

$$\sum_{i=1}^{ng} P_i^t = PD_i^t + PL_i^t, \quad (5)$$

$$PG_p^t = PD_p^t + V_p^t . \left[\sum_{q=1}^{nBus} V_q^t \left(G_{pq} . \cos(\theta_{pq}^t) + B_{pq} . \sin(\theta_{pq}^t)\right)\right], \quad (6)$$

$$QG_p^t = QD_p^t + V_p^t . \left[\sum_{q=1}^{nBus} V_q^t \left(G_{pq} . \sin(\theta_{pq}^t) - B_{pq} . \cos(\theta_{pq}^t)\right)\right], \quad (7)$$

$$P_i^{min} \le P_i^t \le P_i^{max}, \quad (8)$$

$$Q_i^{min} \le Q_i^t \le Q_i^{max}, \quad (9)$$

$$V_p^{min} \le V_p^t \le V_p^{max}, \quad (10)$$

$$S_{pq}^t \le S_{pq}^{max}, \quad (11)$$

$$P_i^t - P_i^{(t-1)} \le UR_i, \quad (12)$$

$$P_i^{(t-1)} - P_i^t \le DR_i, \quad (13)$$

where t is period intervals of time (t=1, 2, 3, …, T), T is a total time operation, FC^t_{total} is total fuel cost of generating units ($/hr) at t^{th} of time, P_i^t is output power of i^{th} generating unit during time interval t (MW), ng is total number of generating units, a_i, b_i, c_i are fuel cost coefficients of i^{th} generating unit, EM^t_{total} is total emission of generating units (kg/hr) at t^{th} of time, α_i, β_i, γ_i are emission coefficients of i^{th} generating unit, Φ^t_{total} is DED ($/hr) at t^{th} of time, h^t is a penalty factor at t^{th} of time, w is a compromised factor, PD^t is power load demand during interval t, PL^t is transmission loss during time interval t, PG_p^t and QG_p^t are power injection of load flow at bus p during time interval t, PD_p^t and QD_p^t are load demand of load flow at bus p during time interval t, V_p^t and V_q^t are voltage at bus p and q during time interval t, P_i^{min} is minimum output power of i^{th} generating unit, P_i^{max} is maximum output power of i^{th} generating unit, Q_i^{max} and Q_i^{min} are maximum and minimum reactive power of i^{th} generating unit, Q_i^t is reactive power output of i^{th}generating unit during time interval t (Mvar), V_p^{max} and V_p^{min} are maximum and minimum voltage at bus p, S_{pq}^t is power transfer between bus p and q during time interval t (Mvar), S_{pq}^{max} is limit of power transfer between bus p and q, UD_i is up ramp limit of i^{th} generating unit and DR_i is down ramp limit of i^{th} generating unit.

III. New Evolutionary Method

The HSABC algorithm is composed using MFS to express many flowers located randomly at certain positions in the harvest season area [23]. The HSABC is inspired by a harvest season situation for providing flowers and it is developed to improve the ABC's performances. To exploit food sources, bees fly randomly during foraging for the food and the position moves from a selected current food source to other position of food sources [19], [24]. In the HSABC, the MFS is consisted by the first food source (FFS) and the other food sources (OFS). Each OFS is directed from the FFS by a harvest operator (ho). The OFS is preceded by foraging for the FFS. The HSABC has four phases of the processes for

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searching the best solution. The algorithm is executed by using several steps based on its processes covered for generating population, food source exploration, food selection and abandoned replacement. The initial step is a set population generation of candidate solutions. This population is created randomly by considered the constrained values of solutions. For each solution is corresponded to the number of parameters to be optimized which is populated using equation (14). The food source exploration is a searching mechanism of neighbor food source. Each food source chosen represents a possible solution to the problem. The new food source is searched by an employed bee as the FFS. After the FFS is found by bee, the OFS is created to express the harvest season situation. The food selection is a food source selection for the best food. Onlooker bee chooses a food source depending on the probability value associated with each nectar quality of food source. In these works, the nectar quality of each food source is evaluated using equation (17) and probability of food source is determined using equation (18). A position of food is searched using equation (15) for the FSS and it is accompanied OFS using equation (16). The scout step is a random searching for a new food source. This food source is used to replace an abandoned value. In general, rules of the HSABC are the MFS is consisted by FFS and OFS; the OFS is preceded by the FFS; every food source is located at different position; all food sources stay in the harvest season area; colony size is consisted by employed bees and onlooker bees; an employed bee of abandoned food source becomes a scout bee. By mathematical expressions, the HSABC are composed as following expressions:

$$x_{ij} = x_{minj} + rand(0,1) * (x_{maxj} - x_{minj}), \quad (14)$$

$$v_{ij} = x_{ij} + \emptyset_{ij}.(x_{ij} - x_{kj}), \quad (15)$$

$$H_{iho} = \begin{cases} x_{kj} + \emptyset_{ij}(x_{kj} - x_{fj}).(ho-1), & \text{for } R_j < MR \\ x_{kj}, \text{otherwise} \end{cases}, \quad (16)$$

$$fit_i = \begin{cases} \frac{1}{1+F_i}, \text{for } F_i \geq 0 \\ 1 + abs(F_i), \text{if } F_i \leq 0 \end{cases}, \quad (17)$$

$$p_i = \frac{fit_i}{\sum_{i=1}^{SN} fit_i}, \quad (18)$$

where x_{ij} is a current food, i is the i^{th} solution of the food source, j∈{1,2,3,…,D}, D is the number of variables of the problem, x_{minj} is minimum limits of x_{ij}, x_{maxj} is maximum limits of x_{ij}, v_{ij} is a food position, x_{kj} is a random neighbor of x_{ij}, k∈{1,2,3,…,SN}, SN is the number of solutions, $\emptyset_{i,j}$ is a random number within [-1,1], H_{iho} is a harvest season food position, ho∈{2,3,…,FT}, FT is the total number of flowers for harvest season, x_{fj} is random harvest neighbor of x_{kj}, f ∈{1,2,3,…,SN}, R_j is a randomly chosen real number within [0,1], MR is a modified rate of probability food, F_i is a objective function of the i^{th} solution of the food, fit_i is a fitness value of the i^{th} solution and p_i is a probability of the i^{th} quality of food.

IV. MODEL AND WAYS

In these simulations, the implementations of the HSABC for solving DED problems are applied to IEEE-30 bus as the sample system model for computing committed power outputs of generating units on specified load demand changes during 24 hours of the period time operation as its procedures in Fig. 2. This system is constructed using 6 generators, 30 buses, 19 bus loads and 41 lines. Single line diagram of the IEEE-30 bus system is shown in Fig. 1.

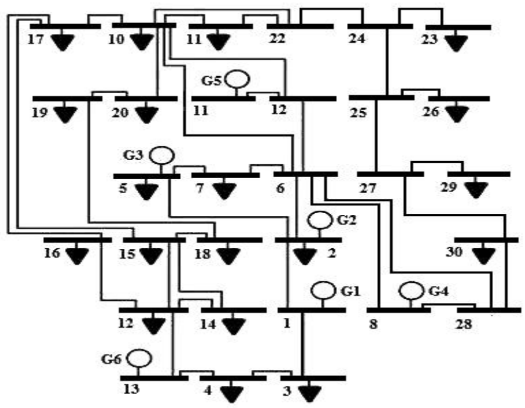

Fig. 1. Standard model of IEEE 30 bus as the tested system

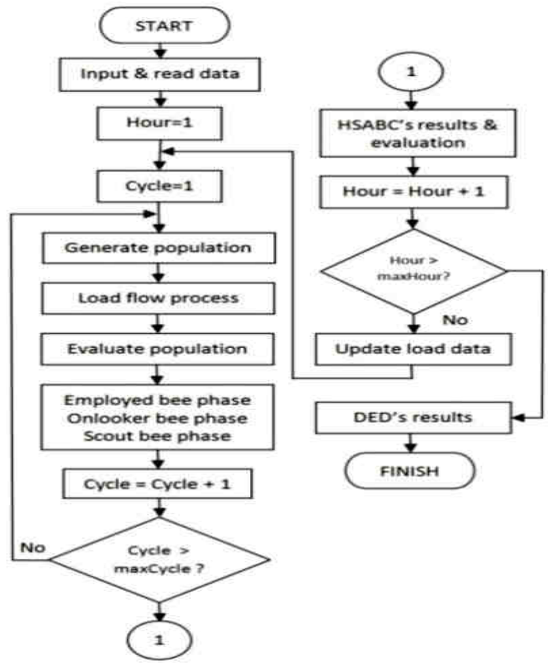

Fig. 2. Flow chart of the HSABC for solving a DED problem

TABLE I
Bee's Parameters for Running Tests

No	Parameters	Quantity
1	Colony size	100
2	Food source	50
3	Foraging cycles	100

TABLE II
Fuel Cost Coefficients of Generating Units

Bus	Gen	a ($/MWh^2)	b ($/MWh)	c
1	G1	0.00375	2.00000	0
2	G2	0.01750	1.75000	0
5	G3	0.06250	1.00000	0
8	G4	0.00835	3.25000	0
11	G5	0.02500	3.00000	0
13	G6	0.02500	3.00000	0

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TABLE III
Emission Coefficients of Generating Units

Bus	Gen	α (kg/MWh^2)	β (kg/MWh)	γ
1	G1	0.0126	-1.1000	22.9830
2	G2	0.0200	-0.1000	25.3130
5	G3	0.0270	-0.0100	25.5050
8	G4	0.0291	-0.0050	24.9000
11	G5	0.0290	-0.0040	24.7000
13	G6	0.0271	-0.0055	25.3000

TABLE IV
Power Limits and Ramp Limits of Generating Units

Bus	Gen	P_{min} (MW)	P_{max} (MW)	UR_i (MW)	DR_i (MW)
1	G1	50	200	85	65
2	G2	20	80	22	12
5	G3	15	50	15	12
8	G4	10	35	16	8
11	G5	10	30	9	6
13	G6	12	40	16	8

TABLE V
Load Demand Changes for 24 hours

Hours	MW	Hours	MW
01.00	245.87	13.00	96.93
02.00	273.88	14.00	329.89
03.00	301.88	15.00	354.11
04.00	329.89	16.00	354.11
05.00	364.82	17.00	364.82
06.00	329.89	18.00	375.52
07.00	343.40	19.00	396.93
08.00	354.11	20.00	418.34
09.00	386.23	21.00	354.11
10.00	407.64	22.00	329.89
11.00	418.34	23.00	287.88
12.00	407.64	24.00	230.76

To solve DED problems, the HSABC uses parameters as given in Table I. Generator's parameters of the sample system are given in Table II for fuel cost coefficients and Table III for emission coefficients. Power limits and ramp limits of generating units are listed in Table IV. Real load demand changes of IEEE-30 bus system are listed in Table 4 as presented in [12]. These loads are provided for 24 hours of the period time operation. In these simulations, fluctuated voltage conditions are allowed by ± 5% for load demand changes. Based on the CEED's objective function, the DED problem is demonstrated using 0.5 of compromised factor. To apply the HSABC, Fig. 2 shows procedures for solving DED problems. This flow chart illustrates the sequencing computations for searching the best solutions of the DED problems based on HSABC's hierarchies for 24 hours. Designed programs of these simulations are divided into several subprograms, those are Main Program; Objective Program; HSABC Program; and Evaluation Program. All the programs are collaborated in the executions to search the best solutions for the DED problems.

V. RESULTS

In these works, the simulations are addressed to show HSABC's abilities for solving the DED problem based on the CEED's objective function with considering operational constraints to schedule committed power outputs of generating units. According to the execution of the designed programs for 24 hours in 100 cycles of HSABC's foraging, the computation's results are given respectively in Table VI, Table VII and Table VIII. These tables are performed using a load demand for each hour as listed in Table V with a day load characteristics as illustrated in Fig. 3. Statistical results for every hour are given in Table VI considered CEED's objective for the DED problem in various obtained iterations. This table performs the results in term of maximum and minimum points, means, medians and standard deviations. A set population of candidate solutions for the first time computation is presented in Fig. 7. The population provides 50 candidate solutions for every foraging cycle. Each solution is located at a certain position to express various possibility foods of the HSABC. All candidates are explored by HSABC to search the best solution of each hour. The progressing computations for determining the best solutions of 24 hour time operations are illustrated in Fig. 8 with shifting obtained computing steps are given in Fig. 9 for the optimal solution. In addition, this figure is performed by CEED's objective function of the DED problems using three food sources, 0.5 of a compromised factor and HSABC's parameters as listed in Table I.

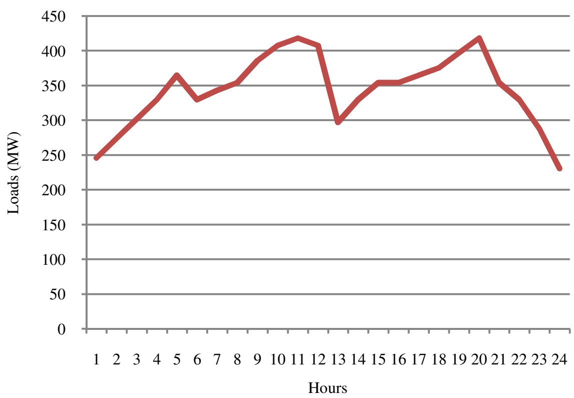

Fig. 3. Day load characteristics for 24 hours

TABLE VI
Statistical results of the CEED for the DED problems

Hour	Max.	Min.	Mean	Median	Std. Dev.	Iter
01.00	692.60	667.33	668.64	667.33	4.47	10
02.00	769.96	727.11	730.57	727.11	9.62	14
03.00	896.60	861.37	864.98	861.37	9.82	14
04.00	1,023.83	1,011.30	1,011.97	1,011.30	2.06	17
05.00	1,121.88	1,110.43	1,111.91	1,110.43	3.51	19
06.00	967.31	930.35	933.46	930.35	7.01	16
07.00	1,008.49	974.02	976.96	974.02	9.08	11
08.00	1,117.05	1,073.56	1,075.94	1,073.56	8.03	15
09.00	1,272.36	1,248.55	1,249.98	1,248.55	5.13	10
10.00	1,401.02	1,377.46	1,379.59	1,377.46	5.10	17
11.00	1,481.03	1,430.93	1,433.49	1,430.93	8.22	12
12.00	1,318.95	1,307.43	1,308.02	1,307.43	2.35	10
13.00	1,314.80	1,295.07	1,296.91	1,295.07	5.68	12
14.00	1,005.66	979.35	981.39	979.35	5.90	19
15.00	1,123.39	1,098.57	1,099.43	1,098.57	3.76	14
16.00	1,024.83	1,019.17	1,019.61	1,019.17	1.11	19

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17.00	1,089.54	1,066.38	1,067.49	1,066.38	3.37	17
18.00	1,148.98	1,133.45	1,133.76	1,133.45	2.14	10
19.00	1,228.54	1,208.03	1,209.33	1,208.03	4.27	11
20.00	1,456.95	1,412.83	1,416.94	1,412.83	9.93	18
21.00	1,086.64	1,025.74	1,027.49	1,025.74	8.87	13
22.00	1,018.23	1,002.05	1,002.74	1,002.05	2.26	19
23.00	830.27	822.31	822.88	822.31	1.89	11
24.00	661.96	628.70	630.63	628.70	7.40	13

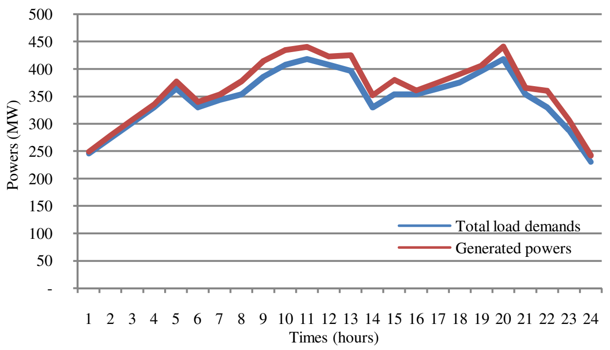

Fig. 4. Power balance between load demands and generated powers

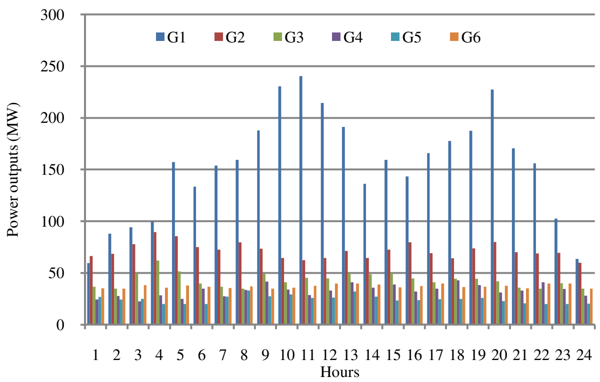

Fig. 5. Scheduled power output variations for 24 hours

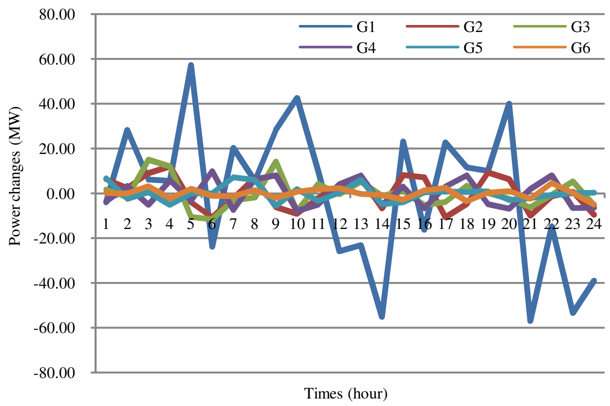

Fig. 6. Power output changes of generating units for 24 hours

TABLE VII
Scheduled powers of generating units for the DED problems

Hour	G1 (MW)	G2 (MW)	G3 (MW)	G4 (MW)	G5 (MW)	G6 (MW)
01.00	59.75	66.34	36.77	24.40	26.98	35.12
02.00	88.06	68.74	35.00	27.78	24.49	35.00
03.00	94.27	77.72	50.00	22.63	25.06	38.19
04.00	99.87	89.72	62.00	28.33	20.00	35.93
05.00	157.16	85.70	51.48	25.07	20.00	37.91
06.00	133.42	75.05	39.94	35.00	20.02	36.74
07.00	153.74	72.76	36.86	27.47	27.10	35.54
08.00	159.42	79.68	35.00	33.75	33.10	37.01
09.00	187.76	73.57	49.19	41.75	27.55	35.00
10.00	230.36	64.42	41.17	33.85	29.31	35.78
11.00	240.25	62.50	45.34	28.83	25.90	37.69
12.00	214.38	64.62	44.91	32.94	26.13	40.00
13.00	191.31	71.36	50.00	40.94	32.13	39.75
14.00	136.31	64.62	48.92	35.84	27.28	39.04
15.00	159.49	72.72	50.00	38.84	23.35	36.24
16.00	143.26	79.81	44.77	32.02	23.78	37.52
17.00	165.99	69.12	40.98	35.00	24.62	40.00
18.00	177.57	64.37	44.37	43.00	25.11	36.42
19.00	187.56	73.73	44.41	38.17	25.90	36.74
20.00	227.51	80.00	41.96	31.25	22.88	37.73
21.00	170.58	69.98	35.74	33.14	20.78	35.28
22.00	155.94	68.77	35.00	41.14	20.00	39.88
23.00	102.52	69.52	40.29	34.54	20.00	40.00
24.00	63.65	60.00	35.00	28.10	20.30	35.00

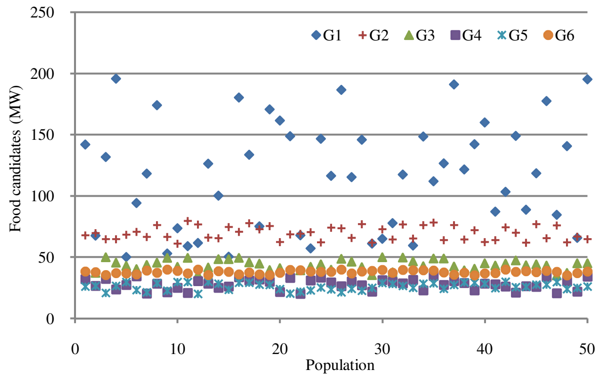

Fig. 7. An initial set population of candidate solutions

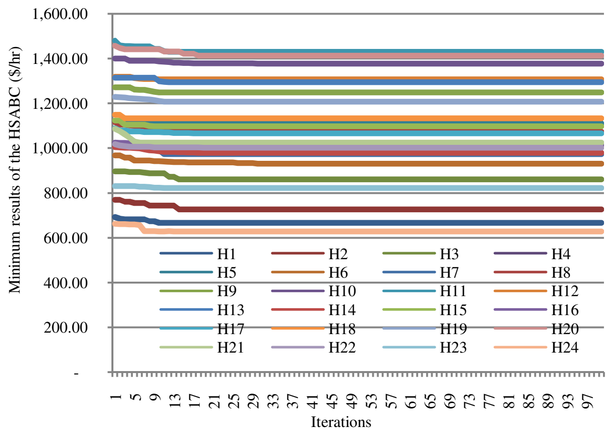

Fig. 8. Convergence characteristics for 24 hours

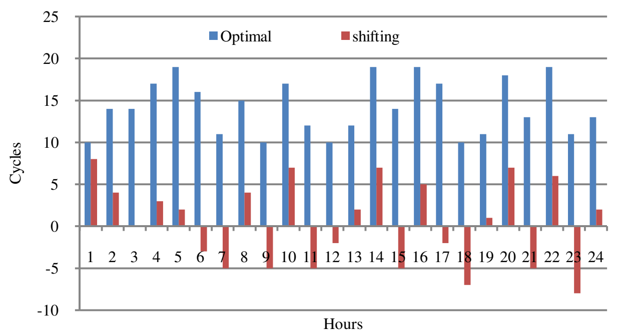

Fig. 9. Obtained and shifted cycles of computations for 24 hours

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TABLE VIII
DED's costs for 24 hours of time operation

Hours	Total Powers (MW)	Emi. Costs ($/hr)	Fuel Cots ($/hr)	Cost at hours ($/hr)	Total Costs ($)
01.00	249.36	766.87	567.79	1,334.66	1,334.66
02.00	279.07	840.56	613.65	1,454.21	2,788.87
03.00	307.87	989.56	733.18	1,722.74	4,511.61
04.00	335.85	1,146.10	876.50	2,022.60	6,534.21
05.00	377.32	1,208.94	1,011.93	2,220.87	8,755.08
06.00	340.17	1,041.15	819.55	1,860.70	10,615.78
07.00	353.47	1,071.29	876.75	1,948.04	12,563.82
08.00	377.96	1,167.40	979.71	2,147.11	14,710.93
09.00	414.82	1,319.08	1,178.01	2,497.09	17,208.02
10.00	434.89	1,360.50	1,394.42	2,754.92	19,962.94
11.00	440.51	1,392.19	1,469.66	2,861.85	22,824.79
12.00	422.98	1,329.80	1,285.06	2,614.86	25,439.65
13.00	425.49	1,368.10	1,222.05	2,590.15	28,029.80
14.00	352.01	1,109.81	848.89	1,958.70	29,988.50
15.00	380.64	1,204.47	992.68	2,197.15	32,185.65
16.00	361.16	1,130.51	907.83	2,038.34	34,223.99
17.00	375.71	1,158.79	972.73	2,131.52	36,355.51
18.00	390.84	1,214.64	1,052.26	2,266.90	38,622.41
19.00	406.51	1,273.51	1,142.55	2,416.06	41,038.47
20.00	441.33	1,393.34	1,432.32	2,825.66	43,864.13
21.00	365.50	1,100.97	950.51	2,051.48	45,915.61
22.00	360.73	1,094.96	909.14	2,004.10	47,919.71
23.00	306.87	944.64	699.97	1,644.61	49,564.32
24.00	242.05	726.79	530.62	1,257.41	50,821.73

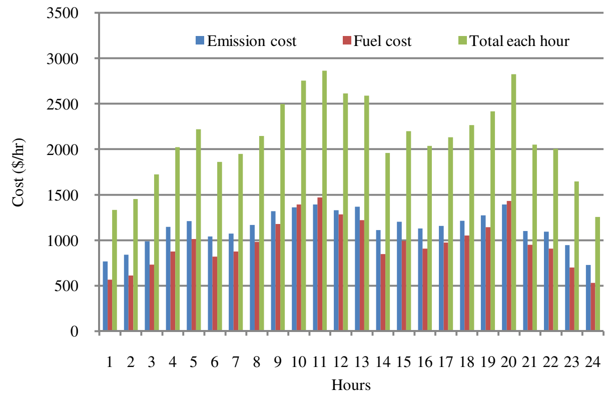

Fig. 10. The Cost per hour of the power generation for 24 hours

Table VII provides permitted power productions of committed generating units to meet load demand changes as shown in Fig. 4. This table performs the scheduled power outputs of generating units to support the system during operations for every time over 24 hours and the power output changes are allowed by using maximum and minimum ramp limits as shown in Fig. 6. In detail, individual scheduled power outputs of generating units are performed in Fig. 5. For supplying the load demand every hour. Moreover, for 24 hours of the operation, the payments of each hour are given in Table VIII. Each component of the total cost is also listed in this budget included fuel cost and emission cost as illustrated in Fig. 10 for the operational fee components.

VI. Conclusions and Recommendations

This paper presents an application of harvest season artificial bee colony (HSABC) algorithm for determining the best solution of the dynamic economic dispatch (DED) problem using IEEE-30 bus system. The DED is solved using operational constraints through the minimized problem of the combined economic and emission dispatch (CEED). The results show that committed power outputs of generating units are produced in various amounts for 24 hour operations. Based on the CEED, DED's starting costs are initialed at different points and the minimum costs are obtained in different iterations. From these works, application on a real large system is devoted to the future studies.

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