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Management optimization of the algerian network electricity with renewable energy

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Abstract - *The sun shines on the world, but more about Algeria. From this luminous reality, exploitation and development of renewable energy such as solar and wind energy is a very important alternative to reduce gas emissions, reduce the bill for power generation and at the same time prepare the country for the post-oil era. Our work can help solve the problem between the energy needs in high growth and hydrocarbon exports which constitute an important source of income. Our technique comes down to improve and optimize the electrical energy consumption of hydrocarbon origin by an intelligent method and incorporating other sources of renewable energy such as solar and wind.*

Résumé - *Le soleil brille sur le monde, mais plus encore sur l'Algérie. De cette réalité lumineuse, l'exploitation et le développement des énergies renouvelables telles que l'énergie solaire et éolienne est une alternative très importante pour réduire les émissions de gaz, la facture de production d'énergie et en même temps préparer le pays à l'ère post-pétrole. Notre travail peut aider à résoudre le problème entre les besoins énergétiques dans les exportations à forte croissance et des hydrocarbures qui constituent une source importante de revenus. Notre technique se résume à améliorer et optimiser la consommation d'énergie électrique d'origine d'hydrocarbures par une méthode intelligente et intégrant d'autres sources d'énergie renouvelable comme l'énergie solaire et éolienne.*

Keywords: Renewable energy - Optimization - Wind - Solar - Economic Dispatch.

1. INTRODUCTION

Electricity is regarded as the invention that changed the world; some centuries ago the world was in total darkness. Currently electricity is virtually present in all our activities.

With the advanced technology on the one hand, and population growth on the other hand, these two factors have made the world a voracious and ravenous appetite for electricity.

This appetite, engulfing already trillions of kilowatt hours (kWh) per year, continues to increase with the industrialization of a growing number of countries. Global electricity consumption is expected to reach 33300 billion kWh in 2030 to 16790 billion kWh in 2008, is expected to double by 2030 [1].

Most predictions to ensure the growth of energy consumption in developed countries in the compositions to about 1% per year, but for developing countries, consumption now exceeds 5% per year [2].

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With the increasing negative effects of fossil fuel combustion on the environment in addition to limited stock of fossil fuel have forced many countries to inquire into and change to environmentally friendly alternatives that are renewable to sustain the increasing energy demand. Energy policy plays a vital role to mitigate the impacts of global warming and crisis of energy availability [3].

Algeria has substantial resources and inexhaustible renewable energy ie solar radiation exceptional covers an area of 2,381,745 km^2, with over 3000 hours of sunshine per year and the existence of significant wind energy potential. Moreover, these energies are clean, renewable and are used where they are and their decentralized nature is well suited to the state of scattered areas of low population density.

Consequently, they can contribute to environmental protection, reduce the emission of greenhouse gases, particularly a successful CO_2 reduction, and to combat global warming, be considered as a future alternative to conventional energy, increased energy independence and preservation of raw materials.

Our work revolves around two main axes: the injection of the maximum power produced from renewable energy sources in the Algerian network.

Optimal management of power produced by conventional power plants by a new method the meta heuristic Artificial Bee Colony algorithm (ABCA).

2. RENEWABLE ENERGY

In Algeria, the renewable energy market is promising and promotion is one of the areas of energy policy and environmental situation. Among the targets set by the government, the local market should reach 375 MW by 2020.

2.1 Solar potential

With its ideal location, Algeria has the largest solar field in the Mediterranean basin.

The average duration of sunshine Algerian territory exceeds 2000 hours per year, to nearly 3500 hours of sunshine in the Sahara desert [4].

Table 1 presents the mean energy ($kWh/m^2/year$) received in Algeria [4].

Table 1: Solar potential in Algeria

Regions	Coastal region	Highlands	Sahara
Areas (%)	4	10	86
Average duration of sunshine (hours/year)	2650	3000	3500
Average received energy ($kWh/m^2/year$)	1700	1900	2650

The power plant mixed Hassi R'Mel is a hybrid power plant in Algeria, the first of its kind.

The plant, built near Hassi R'Mel, was inaugurated on 15 July 2011 [5, 6].

The center combines an array of parabolic trough concentrating solar power of 30 MW, an area of 180000 m^2, in conjunction with a gas turbine plant of 120 megawatts, reducing CO_2 emissions, compared with powerhouses conventional. The output of the solar array is used in the turbine flow.

2.2 Wind potential

Algeria wants to develop wind energy to reduce dependence vis-à-vis natural gas in power generation. The completion of the first wind farm in the country, with a capacity of 10 megawatts (MW), an area of 30 hectares, the site where the wind farm is located Kaberten, 73 km north of the city of Adrar, in the Algerian Sahara.

The wind potential differs by location. and north of the country, the potential wind is characterized by a moderate average wind speeds (1 – 4 m/s) with microclimates around Oran, Annaba, in the high lands and Biskra [7, 8].

In the South, the average wind speed exceeds 4 m / s, especially the southwest, with winds in excess of 6 m/s in the Adrar region [9].

The big south of Algeria is too for wind power applications with mean wind speed Greater than 4 m/s.

The annual mean wind speed and the Weibull shape factor data of Adrar, Bechar, Hassi-Messaoud, In Amenas, In Salah, Timimoun and Tindouf are required to simulate the wind power.

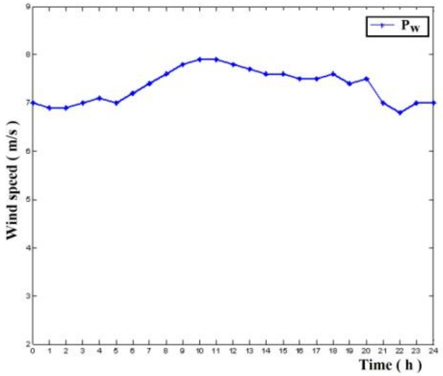

Fig. 1: Daily variations of wind speed in Kaberten (Adrar)

Figure 1 shows the daily variation of wind speed for the site of Adrar.

Thus, the data show that the site (Adrar) has the wind potential very important, because the wind blows at a relatively high speed for long. Indeed, the wind blows at an average speed of 6.5 m/s throughout the day and more than 7 m/s for nearly 10 hours (over 40 % of the time) to 10 m above ground.

3. PROBLEM FORMULATION AND OPTIMIZATION WITH THE SOLAR ENERGY AND WIND ENERGY

3.1 Solar energy

The maximum power provided by a solar panel is given by the following characteristic [10]:

$$P_S = P_1 \times E_C \times \left(1 + P_2 (T_j - T_{jref})\right) \tag{1}$$

E_c, is solar radiation, T_{jref}, is the reference temperature of the panels at 25 °C, T_j, is the cells junction temperature (°C), P_1, represents the characteristic dispersion of the panels and the value for one panel is included enters 0.095 to 0.105 and the parameter P_1 = 0.47 %/°C, is the drift in panels temperature [10].

The addition of one parameter T_3 to the characteristic, gives more satisfactory results:

$$P_s = P_1 \times \left(1 + P_2\ (T_j - T_{jref})\right) \times (P_3 + E_c) \tag{2}$$

This simplified model makes it possible to determine the maximum power provided by a group of panels for solar radiation and panel temperature given, with only three constant parameters P_1, P_2 and P_3 and simple equation to apply.

A thermal solar power station consists of a production of solar system of heat which feeds from the turbines in a thermal cycle of electricity production.

3.2 Wind energy

The power contained in the form of kinetic energy, P (W), the wind is expressed by:

$$P = 1/2 \times \rho \times A \times v^3 \tag{3}$$

With, A is the area traversed by the wind, m^2; ρ is the density of air (=1.225kg/m^3) and v is the wind speed, m/s.

The wind generator can recover some of this wind power and represents the power produced by wind generator:

$$P_{el} = 1/2 \times \rho \times C_e \times A \times v^3 \times 10^{-3} \tag{4}$$

C_e, is the efficiency factor, which depends on the wind speed and the system architecture [3].

3.3 Economic dispatch

Optimization [11] of cost of generation has been formulated based on classical OPF with line flow constraints. The detailed problem is given as follows.

$$F = \text{Min} \sum_{i=1}^{NG} f(P_{Gi}) \tag{5}$$

The cost function $f(P_{Gi})$ is usually expressed as a quadratic polynomial [12].

$$f(P_{Gi}) = a_i \times P_{Gi}^2 + b_i \times P_{Gi} + c_i \tag{6}$$

The minimization the daily total cost of active power generation may be expressed by:

$$F = \text{Min} \sum_{t=1}^{24} \sum_{i=1}^{NG} f(P_{Gi}) \tag{7}$$

The minimum value [13] of the above objective function has to be found out by satisfying the following constraints [14]:

$$\sum_{i=1}^{NG} P_{Gi} + \sum_{k=1}^{NGk} P_{GRk} - P_D - P_L = 0 \tag{8}$$

The generation capacity of each generator has some limits and it can be expressed as:

$$P_{Gi}^{min} \le P_{Gi} \le P_{Gi}^{max} \tag{9}$$

In minimizing the cost, the equality constraint (power balance) and inequality constraint (power limits) should be satisfied.

The transmission loss can be represented by the B-coefficient method as:

$$P_L = \sum_i \sum_j P_{Gi} \times B_{ij} \times P_{Gj} \tag{10}$$

Where B_{ij} is the transmission loss coefficient, P_i, P_j are the power generation of i_{th} and j_{th} units. The B-coefficients are found through the Z-bus calculation technique.

P_{Gi}^{min} and P_{Gi}^{max} - Lover and upper limit of active power generation at bus i; a_i, b_i and c_i - The cost coefficients of the i_{th} generator; P_{Gi} - the power output of generator i in MW; P_D - Active power load total; P_{Gi} - Active power generator at bus i; P_{GRk} - Active power generator at bus k; P_L - Real losses; NG - Number of thermal generators connected in the network; NGR - Number of renewable generator.

4. THE ARTIFICAL BEE COLONY ALGORITHM

The Artificial Bee Colony is introduced recently for optimization algorithm with unconstrained optimization problems [15], for solving constrained optimization problems [16], a constraint handling method was incorporated with the algorithm, and simulates the behaviour of bee colony.

There are some tasks in a real bee colony, performed by specialized individuals. They try to maximize the nectar amount stored in the hive with having efficient division of self-organization and labour. The ABC algorithm adopts the minimal model of swarm-intelligent forage selection in a honey bee colony that consists of three kinds of bees: employed bees, onlooker bees, and scout bees. Half of the colony comprises the onlooker bees and the other half includes employed bees.

The second kind of bees, in the hive, are responsible from exploiting the nectar sources explored before and giving information about the quality of the food source site which they are exploiting to the other waiting bees (onlooker bees). Wait in the hive, Onlooker bees decide a food source to exploit depending on the information shared by the employed bees. Scouts randomly search the environment in order to find a new food source depending on an internal motivation or possible external clues or randomly. The ABC algorithm simulating the behaviour is given by main steps below [17]:

1- The source food positions are initialized.

2- A new food source is produced by each employed bee in her food source site and exploits the better source.

3- A source depending on the quality of the solution of each onlooker bee is selected. She produces a new food source in selected food source site and exploits the better source.

4- Determine the source to be abandoned and allocate its employed bee as scout for searching new food sources.

5- The best source find so far is memorized.

6- Steps 2-5 are repeated until met the stopping criterion.

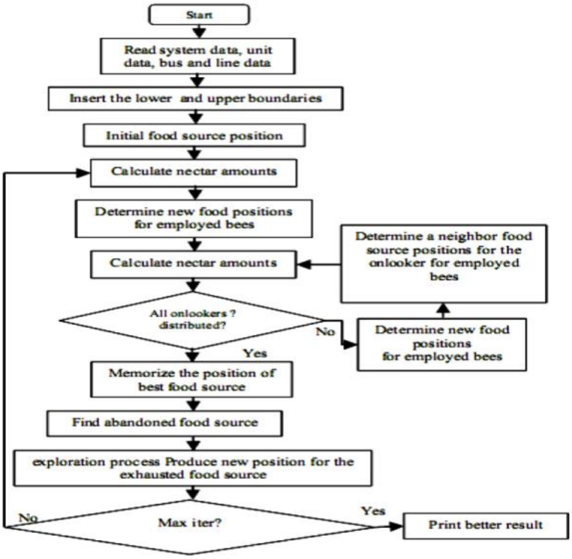

Fig. 2: Structure of ABC Method

The $x_i \ (i = 1, \cdots, SN)$ solutions are randomly produced, in first step of the algorithm, in the range of parameters where SN is the number of the food sources. For each employed bee, whose total number equals to the half of the number of food sources, in the second step of the algorithm, a new source is produced by (11) [17]:

$$v_{ij} = x_{ij} + \phi_{ij} \times (x_{ij} - x_{kj}) \qquad (11)$$

Where ϕ_{ii} is a uniformly distributed real random number within the range [-1,1], k is the index of the solution chosen randomly from the colony ($k = \text{int}(\text{rand} \times SN) + 1$), ($j = 1, \cdots, D$) and D is the dimension of the problem.

This new solution is compared to x_i solution and the employed bee exploits the better source after producing v_i. An onlooker bee chooses a food source in the third step of the algorithm, with the probability (12) and produces a new source in selected food source site by (11). As for employed bee, the better source is decided to be exploited.

$$P_i = \frac{fit_i}{\sum_{j=1}^{SN} fit_j} \tag{12}$$

Where fit_i is the fitness of the solution x_i. After all onlookers are distributed to the sources, sources are checked whether they are to be abandoned. The source is considered to be exhausted, if the number of cycles that a source cannot be improved is greater than a predetermined limit. The employed bee associated with the exhausted source becomes a scout and makes a random search in problem domain by (13).

$$x_{ij} = x_{minj} + rand(0,1) \times (x_{maxj} - x_{minj}) \tag{13}$$

5. RESULT APPLICATION

The Artificial Bee Colony algorithm (ABCA) was coded in the MATLAB environment. The test was performed on the Algerian network [18]. This network consists of 114 buses, 15 generators, 159 transmission lines and 16 transformaters. The load demand of the system is 3727MW. **Table 2** shows the technical economic characteristics of the Algerian network.

To demonstrate the effectiveness of the proposed technique, four different cases have been considered, as follows:

Case1- Calculate the total cost Algerian electrical network without renewable energy and without operating optimization (cost AEPWO).

Case2- Calculate the total cost Algerian electrical network with renewable energy and without operating optimization (cost AEPRWO).

Case 3- Minimize the total cost Algerian electrical network, without renewable energy. $P_{GRi} = 0$, (Cost AEP).

Case 4- Minimize total Minimize total operating cost, with renewable energy. $P_{GRi} \neq 0$ (cost AEPR).

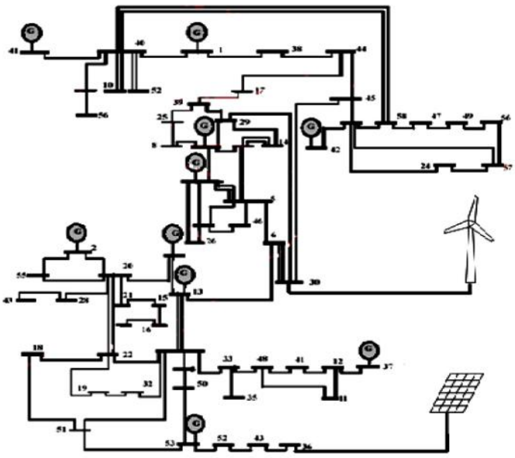

Fig. 3: Algerian Electrical Network 59-bus

Table 2: Generators parameters of the Algerian Electrical

Bus	P_{Gi}^{min} (MW)	P_{Gi}^{max} (MW)	Q_{Gi}^{min} (MVAr)	Q_{Gi}^{max} (MVAr)	a_i ($/MW²h)	b_i ($/MWh)	c_i ($/h)
1	8	72	-10	15	0.0085	1.50	0
2	10	70	-35	45	0.0170	2.50	0
3	30	510	-35	55	0.0085	1.50	0
4	20	400	-60	90	0.0085	1.50	0
13	15	150	-35	48	0.0170	2.50	0
27	10	100	-20	35	0.0170	2.50	0
37	10	100	-20	35	0.0030	2.00	0
41	15	140	-35	45	0.0030	2.00	0
42	18	175	-35	55	0.0030	2.00	0
53	30	450	-100	160	0.0085	1.50	0

Table 3: Simulation results for the four cases

	Case 1	**Case 2**	**SLP_EED**	**Case 3**	**Case 4**
P_{G1} 'MW'	51.1142	27.3124	46.576	20.8991	60.0598
P_{G2} 'MW'	64.7264	19.5464	37.431	37.2021	63.7066
P_{G3} 'MW'	266.1201	255.5929	134.230	72.7662	55.1417
P_{G4} 'MW'	397.8771	63.5509	137.730	98.9941	102.8228
P_{G5} 'MW'	70.9853	88.8229	0.000	55.8777	33.6149
P_{G6} 'MW'	58.6933	39.7594	23.029	65.0460	12.9023
P_{G7} 'MW'	75.9099	25.0468	35.238	62.1343	52.1777
P_{G8} 'MW'	31.9809	15.9248	39.972	93.0720	64.5729
P_{G9} 'MW'	152.9527	63.8732	117.890	105.1148	131.4789
P_{G10} 'MW'	191.6771	35.0627	131.650	92.6427	87.2710
P_{GR1} 'MW'	0.0	10.0	0.0	0.0	10.000
P_{GR2} 'MW'	0.0	30.0	0.0	0.0	30.000
P_D 'MW'	684.10	684.10	684.10	684.10	684.10
P_L 'MW'	19.65	19.65	19.65	19.65	19.65
Cost '$/h'	4372460.33	3740686.34	1775.86	1768.13	1604.65
T 's'	0.0234	0.010920	/	1.5569	1.538170

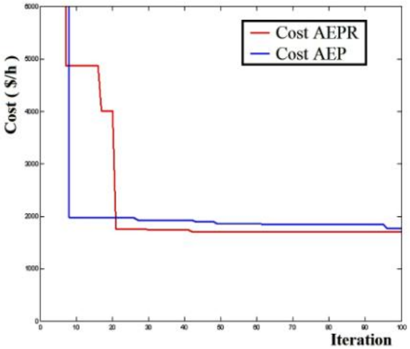

Fig. 4: The function cost values in different iterations for ABCA for case 3 and 4

To study the power generated by solar sources, we did the study in two periods (summer and winter)

1- The study of the production of solar power by sources in summer,

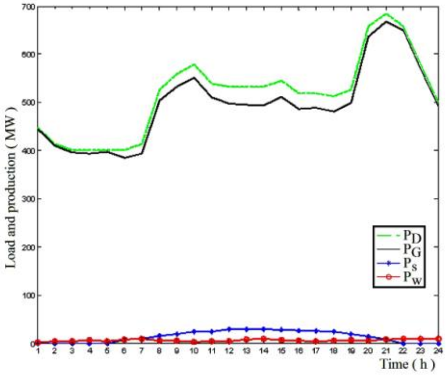

Fig. 5: Load demand and power production (July)

2- The study of the production of solar power by sources in winter,

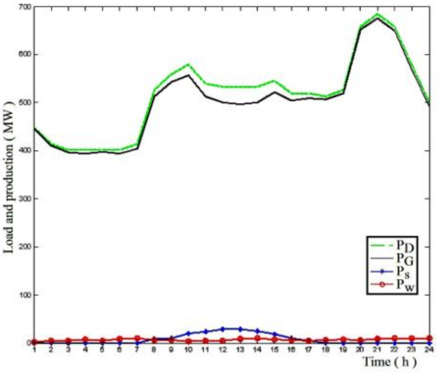

Fig. 6: Load demand and power production (December)

6. CONCLUSION

In this paper, we presented a new technique for solving the economic problem dispatching a real network (network Algerian bus 59), by injecting a portion of the power by sources of renewable energy and optimize the production of power remaining, i.e produced the thermal power plants with a new meta heuristic method (ABCA).

The results show clearly the robustness and efficiency of the proposed approach in term of precision.

The obtained results were compared thoroughly to those of other researchers.

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