Optimization Strategy of an Electric Energy Multi - Source Power Station

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Abstract – This study presents a strategy for economic and environmental optimization of a multi - source power station while satisfying demand and deducting the on line active losses using the algorithm method of an ant colony, implemented in a MATLAB environment version 7.6. Values of μ, the coefficient of ponderation was in the range 0< μ <1 and at μ= 0.6, we obtained the optimal conditions which include, for the IEEE 30 nodes network, the cost of production was 819.996 $/h, emissions 0.269 Ton/h and the total Cost 968.33036$/h, on lines losses of 6.92 MW with a calculation time of 6.38 seconds. For the Algerian 114 nodes network, we obtained the cost of production as 19668.9445 $/h, emissions of 0.673 Ton/h, the total cost of 20596.032 $/h, on line losses of 17.1MW with a calculation time of 9.179 second. The results revealed that whatever the size of the network, ACO gave optimal values and from networks of more than 10 generators, ACOS fastest convergence time. We concluded that the strategy presents a good result compared to other Meta – heuristic methods.

Keywords: Strategies, Optimization, Electric energy, Multi - Source station, Ants Colonies of Power station.

Nomenclature

OPF: Optimal Power Flow
ACO: Ant Colony Optimization
ACS: Ant Colony System
AS: Ant System
ED: Economic Dispatch
CEED: Combined Economic Emission Dispatch
OEP: Optimisation par Essaim de Particules
IPPD: Improved Pre-prepared Power Demand
FACTS: Flexible Alternating Current Transmission System
TSP: Travelling Salesman Problem
GA: Genetic Algorithm
PSO: Particul Swam Optimization
ABC: Algorithm Bee Colony
PVC: Problème de Voyageur de Commerce
OCF: Optimisation par colonie de fourmis
RAM: Random Access Memory

1. Introduction

Energy is the faculty that possesses a system of bodies to provide a mechanical work or its equivalent. It can be in several forms, we have among others: wind energy, hydraulic energy, thermal energy and solar energy. These forms of energy have preoccupied humanity for a long time. Indeed, the idea to exploit these sources of energy was born with man's desire to solve some domestic and industrial problems [9], [13] and [17]. These have been, continuity and the quality of electric energy supply are the first missions of an electricity dealer enterprise [6]. In spite of the stake according to new power stations, the structure of production, transportation and management of the energy in Cameroon doesn't always best satisfy its client. Indeed according to the " technical and commercial control Report by 10 000 subscribers of the AES-SONEL company" of ARSEL [1], one can note that:

- 93% of Cameroonians using electric energy are dependent on AES-SONEL;
- The duration of a monthly interruption is on average 6.9 days, practically one week of waiting before delivery;
- 67% of interruptions considered "harmful" present more than two hours of waiting before the delivery;
- the Littoral, Northwest, West, South and Southwest Regions are particularly affected by ample interruptions, which rages more in the rural and suburban environment;
- Subscribers are victims of about one interruption per day in the whole country and 4hrs/day in the city of Douala;
- 78.7 % of these subscribers undergo more than 4 interruptions in the city of Douala per week.

An interview with the Director General of ARSEL in May 2013 during a press conference organized by the Africa - France association revealed that:

- 6.5 % of the energy produced is lost at the time of transportation;
- 29 % of losses on the electric network evaporate at the level of distribution.

The duration and the frequency of these interruptions make the network of distribution in a whole less reliable. Industrial development and demographic growth contribute to a strong demand for electrical energy. This has as consequence an increase in the power to be generated by the power plants. Facilities for production, transportation, and distribution of electric energy require some heavy investments. It is important for electric energy production companies to reduce the cost of working which has as consequence an increase of their beneficiary margin. Thus, the problem of production, transportation and distribution of electrical energy led to the research and the development of alternative energy sources. On the other hand, thermal power stations use fossil resources as fuel to produce electrical energy. The combustion of these fossils causes damages on nature through the production of greenhouse gases which brings about the destruction of the ozone layer, global warming and other ecological problems. It is important to reduce the production of these gases considerably in accordance with the Kyoto protocol of 2005 on the reduction of pollutant gas emissions through their harmful characters and the depletion of fossil resource reserves with time since they are non-renewable [3]. Since several works like those of Walid et *al.* [18]; Peng Li et *al.* [24]; Courtecuisse [4], Duval [20] conducted on hybrid system modeling used conventional or classic methods that are deterministic methods like the simplex method, the gradient method, the branch and bound etc… and the stochastic or meta - heuristic methods such as networks of neurons, the genetic algorithm, algorithms of bee colonies, swarms of particles, algorithms of ant colony etc. and do not take into account the polluting emissions, it is necessary to conduct a survey on the Strategy of optimization of an Electric energy Multi Source Power station. Works carried out within the framework of the economic and environmental optimization of power plants recognized under expressions such as the problem of optimal power flow (OPF) or economic and environmental dispatching (EED), we can note that:

Slimani et *al.* [15] worked on the optimal power flow through a genetic algorithm while taking into account the economic and environmental aspects. She used the coefficient of ponderation to combine the two objective functions. She finds a high total cost and emission cost. Bouktir et *al.* [5] used the algorithm of a bee colony for economic and environmental optimization and they improved the total cost and the cost of production. Krishnamurthy [21] treated the economic and environmental optimization by the PSO. It uses the penalty factor to combine the objective functions. It improves the cost of production but it finds losses of elevated in line powers. Alkhalil [2] used the Secant method combined to an IPPD picture (Improved Pre - Prepared Power Demand) to carry out a medium-term supervision of an electric energy system associated to a photovoltaic power station. Courtecuisse [4] used fuzzy logic during the supervision in real time of a multi-source power station to basis of the wind and gets a gain in time of calculation. Mouassa et *al.* [16] used the algorithm of the artificial bee colony while introducing the notion of FACTS (Flexible Alternating Current Transmission System) heard supple transmission system in alternating current to treat the optimization problem of power flow in the presence of wind turbine while insisting on the security of the system and while respecting variables of the control vector.

Alaya [22] while treating the multi objective optimization problems by ant colonies, particularly the case of multi-dimensional backpack and the quadratic backpack, build us on the different approaches of resolution and ordering of problems multi objective.

Draidi [23] worked on the economic distribution of electric energy while using neuron networks. He obtained a very fast time of convergence roughly millisecond. Missoum [12] worked on the optimal distribution of active power with the ant colony algorithm while taking into account only the economic aspect. His works did not take into account the environmental aspect. He thereafter compared his results by a deterministic method (the Newton method) and a meta-heuristic (the genetic algorithm). This reveals that the algorithm of the ant colony presents the best results than the conventional method and the meta-heuristic method. Taking into consideration all that precedes a question can be asked on how to produce electric energy at a minimum cost and at a minimum rate of greenhouse gas emissions while satisfying the demand.

The objective of this work comes to determine optimal powers for cost of production and minimal emissions and on line power losses, in other words the optimal distribution of power, the optimal flow of power, and more precisely the economic and environmental dispatching. The specific objectives assigned to this study are:

- The determination of an optimal active power for the supply of electric energy at a minimal cost of production and cost pollutant gas emission (optimization of the cost of production function and the cost of emission function) while satisfying the demand;
- The determination of on line active losses.

To conduct this study, we will initially use the method of the ant colony on the IEEE-30 nodes network (6 generators) representing part of the American electric food system (Mid-West), then on the Algerian network 114 nodes (15 generators), then on the IEEE-57 nodes network (7 generators) and finally on the Algerian network 59 nodes (10 generators). Thereafter a presentation of the tools and the method that will be used for the resolution of the problem. Finally, a presentation discussing the results obtained in relation to the results of other studies with other methods.

2. Material and Methods

2.1 Material

To conduct a good job, material resources and software programs were used. Also, a portable computer having the following features: Pentium 4, 2 Gigas bytes (GO) of RAM, Processor body duet 2X 1.73 Giga Hertzes (GHz) and the software MATLAB version 7.6 were used to program the algorithm of the ant colony.

2.2 Methods

2.2.1 Optimization Applied to the Optimal Distribution of Power

The problem of optimization in a power plant consists in finding the optimal powers at minimum cost of production and poisonous gas emission while satisfying demand. This, while minimizing the multi-objective function that represents goals to reach by taking into account constraints. Mono-objective Functions are cost of production or working function and the cost of emission or atmospheric rejection function.

2.2.1.1 Cost of Production Function

It is defined by the following equation:

$F_{Pi} = a_i + b_i P_i(t) + c_i P_i^2(t)$ (1) where a_i, b_i and c_i are coefficients of production cost and P_i, the power delivered by the generator i.

2.2.1.2 Cost of Emision Function

It is defined by the following equation:

$E_{mi} = \alpha_i + \beta_i P_i(t) + \gamma_i P_i^2(t)$ (2) where α_i, β_i and γ_i are coefficients of cost of emission of the generator.

2.2.1.3 Combination of Mono-objective Functions to Multi-objective Function

There are mainly two combination methods of mono-objective functions to multi-objective functions; the method of the equilibrated sum and the method of the penalty factor.

2.2.1.3.1 Method of the Equilibrated Sum

$F_T = \mu F_{Pi} + (1 - \mu)\omega E_{mi}$ (3) where F_T, µ and ω, µ designate the global function, the coefficient of ponderation and the factor of the emission cost respectively.

2.2.1.3.2 Method of the Penalty Factor

$F_T = F_{Pi} + h_i E_{mi}$ (4) with $h_i = F_{Pi}/E_{mi}$ representing the factor of penalty.

2.2.1.3.3 Constraints

there exist two types of constraints namely those of equality defined by $\sum_i^n P_i = P_D + P_L$ (5) with n, P_D and P_L designating the number of generators, the active power consumed by the load and the active on line losses respectively and those of inequality are defined by $P_{gimin} \leq P_{gi} \leq P_{gimax}$, i = 1, n.

2.2.2 The Ant Colony Algorithm Method Applied to the Optimal Distribution Active Power.

A meta-heuristic ant colony is a stochastic process that constructs a solution, while adding components to partial solutions. This process takes into account a heuristic on the instance of the problem of changing dynamically phenomena tracks to reflect the experience acquired by ants. The formalization of ACO applied to the OPF passes through the representation of the problem and the basic behavior of ants. Ants can be characterized as a stochastic construction procedure building solutions on the graph G = (C, L). In general, ants attempt to elaborate some feasible solutions, but if necessary, they can produce some impracticable solutions. These components and connections can be associated into tracks of pheromone τ (putting in place an adaptive memory describing the state of the system) and into the visibility value η (representing an information a priori on the problem, or coming from another source other than that of ants; it is often the cost of the power generated by each power station of the state). Tracks of pheromone can be associated either to components, or to graph connections representing the problem to solve. Each ant has a memory used to store the course effectuated from an initial state and conditions for stop. Ants move following to the rule of probabilistic decision function of local pheromone tracks, of the state of the ant and constraints of the problem. At the time of the addition of a component to the solution ants can put up to date in progress, ants can update a track associated to a component or a corresponding connection. Once the solution is constructed, they can update the tracks pheromone of components or connections used. Finally, has a minimum capacity to construct a solution to a problem. The OPF problem is represented by a game of solutions, an objective function assigning a value to every solution and a game of constraints. The objective is to find the global optimum satisfying the constraints. The different states of the problem are characterized like a sequence of components. In this representation ants construct solutions while moving on a graph G = (C, L), where nodes are components of C that represent the powers generated by the interconnected power plant and where the L collection connects components of C that represent the remainder of the power required to distribute on the remaining power plant. Constraints of the problem are directly implemented in the rules for ant displacement (either by preventing movements that violate constraints, or by penalizing such solutions). The algorithm of the ant colony for economic and environmental optimization is constituted of four following stages:

Stage 1: Initiation

The first stage consists of coding the variable P_{gi} (power produced by the generator i) using the real values in the authorized value space. Every P_{gi} parameter has an upper limit $P_{gi\ max}$ and a limit lower $P_{gi\ min}$. Before every round, the initial point (nest) of the colony is generated randomly in the feasible region. Each ant is placed at the initial point while the initial value of the pheromone τ_o is also given to this stage. While taking the concept of the process to several phases as a basis, the space of research of the optimization of the power out-flow can be established. All possible permutations constitute this space of research. Every phase contains several points.

Stage 2: Assessment of the Function-objective

In this stage the direct influence of the value of the bi-objective function depends on the level of quantity of phenomena that is added to the particular directions that ants select.

Stage 3: Distribution of Ants

In this stage, ants are distributed while taking levels as a basis. The rule of displacement is the following:

$p_{ij}^k(t)=[((\tau_{ij}(t))^{\alpha}(\eta_{ij})^{\beta}]/\sum_{l\in j_i^k}((\tau_{il}(t))^{\alpha}(\eta_{il})^{\beta}$ (6) if $j\in j_i^k$ or $p_{ij}^k(t)=0$ (7) if $j\notin j_i^k$ where α and β are two parameters controlling the relative importance of the intensity of the $\tau_{ij}(t)$, and of the visibility η_{ij} .

According to the equation of the displacement rule given above, every ant chooses a new point towards which she moves while taking in consideration values of τ and η. Now, so m is the number of ants (m>Ng), for every iteration will these m ants execute m movements then in the interval of the time (t, t+1). While constructing a solution to the problem, the phenomena of trajectories visited can be adjusted dynamically by the following equation to widen the space of research: $\tau_{ij}(t+1)=(1-\rho)\tau_{ij}(t)\ +\rho\tau_0$ (8). This process is called rule of the local updating of the phenomena. After n iterations, all ants have completed a visit. The best track done by the ant is updated by a process called the rule of global regulation update using the following equation: $\tau_{ij}(t+1)=(1-\rho)\tau_{ij}(t)\ +\ \Delta\tau_{ij}(t)$ (9) where bones (i,j) belong to the best T^+ tour of L^+ length and where $\Delta\tau_{ij}(t)=q_0/L^+$(10). This process participates in intensification by selection of the best solution. This solution will also be recorded in the table of taboo for the more belated comparison with the following iteration.

Stage 4: Criteria of Stop

The process of the calculation continuous until the number of iterations reaches the predefined maximal value or that a solution of acceptable objective function is found.

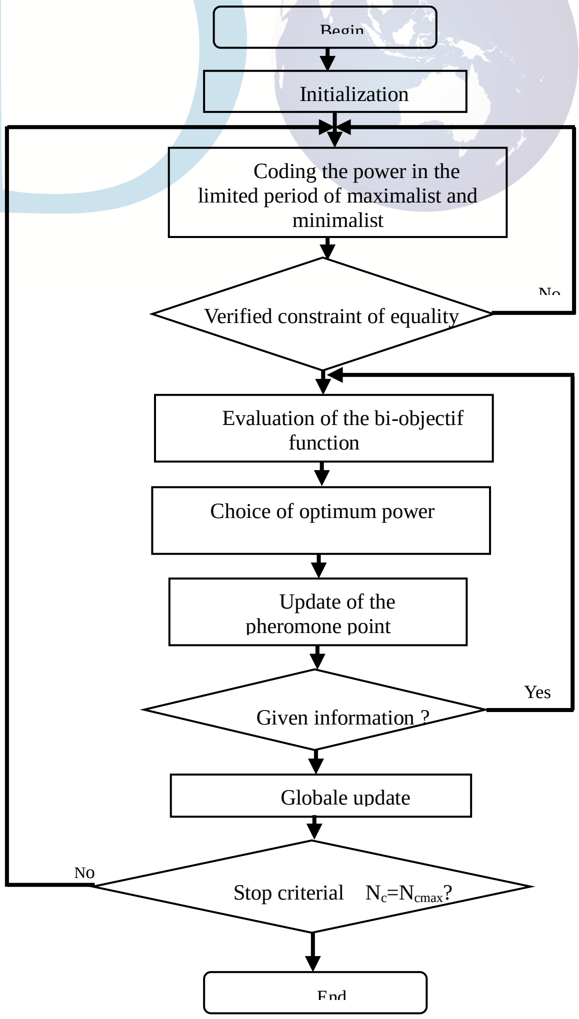

Figure 1: Algorithm of the ant colony for the optimal distribution of power.

3. Results and Discussions

To program the algorithm of the ant colony, we combined two objectives functions (cost of productions and cost of emissions) by the weighted sum method expressed by the following equation: $g(\lambda)=(x_k - \lambda.\Delta f(x_k))$ (11). The coefficient of **μ** ponderation varies between 0 and 1 permits to determine the percentage of each objective optimization. For example D=0 corresponds to an optimization 100 % environmental and 0 % economic. μ=1 corresponds to an optimization 100 % economic and 0 % environmental, μ = 0.1 corresponds to an optimization 10 % economic and 90 % environmental. The factor of the cost of emission **ω** of gas and the power asked for this network test is respectively 550.66 $/Ton and 283.4 MW.

The algorithm of the ant colony has been applied to the network IEEE-30 nodes. We search for the optimal variable parameters of the colony of ants algorithm first while varying the different combinations of β, ρ and q_0 given by **Dorigo and Stützle** [7] in the ant colony optimization meta-heuristic for an economic optimization and got results of the following results as shown by the tables below were obtained.

Table 1: Results of the ACO-OPF for the ten combinations β, ρ and q_0.

	β= 11 ρ = 0.4 q₀ = 0.4	**β = 6 ρ = 0.3 q₀ = 0.7**	**β = 10 ρ = 0.8 q₀ = 0.6**	**β = 10 ρ = 0.6 q₀ = 0.3**	**β = 11 ρ = 0.8 q₀ = 0**
P_{G1} (MW)	180.699	172.0554	177.9946	166.875	180.9561
P_{G2} (MW)	48.067	51.109	42.130	55.427	43.605
P_{G5}(MW)	19.618	23.398	19.025	20.498	20.353
P_{G8}(MW)	14.589	17.355	21.983	16.656	15.983
P_{G11} (MW)	17.986	13.615	17.850	15.760	14.999
P_{G13}(MW)	12.240	15.154	13.823	17.264	17.181
Active lost (MW)	09.802	09.202	09.407	09.080	09.680
Production cost ($/h)	803.770	803.41	804.45	804.86	804.150

Table 1: Results of the ACO-OPF for the ten combinations β, ρ and q_0 (following).

	β = 9 ρ = 0.4 q₀ = 0.4	***β = 12 ρ = 0.5 q₀ = 0.3***	**β = 9.5 ρ = 0.8 q₀ = 0.1**	**β = 11 ρ = 0.5 q₀ = 0.1**	**β = 10 ρ = 0.6 q₀ = 0**
P_{G1} (MW)	177.120	**176.233**	175.84	180.666	174.743
P_{G5}(MW)	24.928	**20.970**	19.700	16.410	23.516
P_{G8}(MW)	17.342	**22.270**	21.170	17.103	23.697
P_{G11} (MW)	11.006	**13.050**	15.790	15.670	13.747
P_{G13}(MW)	17.207	**12.080**	15.623	13.591	12.503
Active lost (MW)	09.346	**09.434**	09.330	10.120	09.126
Production cost ($/ h)	804.24	**802.308**	803.570	804.480	803.060

From results of the table above, we can say that the optimal variable parameters of the algorithm of the ant colony are gotten for β = 12, ρ = 0.5 and q_o = 0.3 but it is this combination that permits to have the most reduced production cost. The table below presents the decreasing values of μ of 1 to 0 of the optimal power delivered by each of the generator P_{g1}, P_{g2}, P_{g5}, P_{g8}, P_{g11}, P_{g13}, the cost of production, the line active losses, the cost of emission and the total cost.

Table 2: Algorithm Results of the active ants colony for μ from 1 to 0.8.

	μ = 1	μ = 0.9	μ = 0.8
P_{G1}(MW)	176.233	171.453	166.727
P_{G2}(MW)	48.230	53.190	49.140
P_{G5}(MW)	20.970	22.420	20.100
P_{G8}(MW)	22.270	20.670	26.010
P_{G11}(MW)	13.050	11.780	12.630
P_{G13}(MW)	12.080	13.130	17.650
production cost ($/h)	802.308	802.822	804.092
Line losses (MW)	09.433	09.243	08.857
Emission (Ton /h)	00.363	00.351	00.338
Total cost ($/h)	1002.404	996.351	990.188

Table 3: Results of the algorithm of the colony of ants for μ = 0.7, μ = 0.6, μ = 0.5 and μ = 0.4.

	μ = 0.7	μ = 0.6	μ = 0.5	μ = 0.4
P_{G1}(MW)	150.615	131.946	125.555	112.373
P_{G2} (MW)	55.450	56.830	52.830	62.030
P_{G5}(MW)	21.810	22.610	28.970	31.310
P_{G8}(MW)	33.470	34.370	30.810	29.970
P_{G11}(MW)	13.090	20.350	26.500	18.500
P_{G13}(MW)	16.920	24.220	25.030	35.160
production cost ($/h)	808.274	819.996	828.805	845.905
line losses (MW)	07.955	06.926	06.296	05.944
Emission (Ton/h)	00.305	00.269	00.257	00.242
Total cost ($/h)	975.962	966.330	970.188	979.382

Table 4: Algorithm results of the ants colony for μ from 0.3 to 0.

	μ=0.3	μ=0.2	μ=0.1	μ=0
P_{G1}(MW)	99.967	88.180	79.998	68.195
P_{G2}(MW)	64.980	62.480	62.220	65.220
P_{G5} (MW)	30.820	37.070	43.660	49.220
P_{G8}(MW)	26.710	34.380	33.840	34.780
P_{G11}(MW)	29.780	26.510	29.980	30.000
P_{G13}(MW)	36.590	39.580	38.020	39.580
Production cost ($/h)	862.713	882.730	905.566	938.718
Line losses (MW)	05.447	04.801	04.319	03.896
Emission (Ton/h)	00.228	00.217	00.211	00.206
Total cost (S/h)	988.462	1002.465	1021.732	1051.94

From results gotten above in the tables, we can note that active powers generated are in their admissible limits and the total cost in the case of the minimization of the emission rate (μ=0) is raised more than in the case of the minimization of the production cost (μ=1) with a ratio of 4.94 %. On the other hand, the value of power losses corresponding to μ=0 is reduced more than that of μ = 1 for a time of calculation is 6.38 seconds. For the worry of poisonous gas to protect the environment, we minimized the cost of production at the same time. We can note that the optimal total cost is gotten for μ=0.6 (60 % economic and 40 % environment) and is equal to 968.330 $/h with a rate of emission of 0.269 ton/h and power losses of 6.926 MW. The power tables below present the comparative results for μ=1 (economic optimization 100 % and environmental optimization 0 %) to those of Missoum [12] in order to validate our results.

Table 5: Comparative results ACO et ACO $_{\text{Missoum [12]}}$.

	ACO	ACO$_{\text{Missoum[12]}}$
P_{G1}(MW)	176.233	177.864
P_{G2}(MW)	48.23	48.637
P_{G5} (MW)	20.97	20.893
P_{G8}(MW)	22.27	22.123
P_{G11}(MW)	13.05	13.625
P_{G13}(MW)	12.08	12.120
Production cost ($/h)	802.309	803.123
Line losses(MW)	09.434	09.462

From the table above, we can note that the differences compared to our results concerning the powers delivered by the various generators Pg1, Pg2, Pg5, Pg8, Pg11, Pg13;the on-line losses and the production cost are respectively 0.92%, 0.84%, 0.36%, 0.65%, 0.44%, 0.33%, 0.29% and 0.1% inferior 10%.It is one of the reasons which we can confirm our results true for the other values of μ. Owing to the fact that economic and environmental optimization obtained with μ=0.6 is optimal, the table below gives results of the comparative study of the economic and environmental control system with other methods such as the genetic algorithm, the swarms of particles and the algorithm of the colony of bee used respectively by certain authors following the example Bouktir *et al.* [5], Slimani [15] and Krishnamurthy [21].

Table 6: Comparatives results ACO, GA$_{Slimani[15]}$, PSO$_{Krishnamur-thy[21]}$ and ABC$_{Bouktir\ et\ al.[5]}$.

	PSO$_{Koridak}$ [10]	GA$_{Koridak}$ [10]	**ACO**	ABC$_{Souhil}$ [16]
P_{G1} (MW)	517.803	486.133	502.920	463.283
P_{G2}(MW)	449.251	452.059	507.417	454.125
P_{G3}(MW)	82.989	98.971	54.519	100.000
P_{G4} (MW)	160.699	262.000	217.166	190.570
P_{G5}(MW)	402.369	462.762	476.599	416.076
P_{G6}(MW)	163.967	175.270	162.539	212.431
P_{G7}(MW)	176.723	110.311	170.177	190.546
P_{G8}(MW)	257.323	177.142	169.329	209.482
P_{G9}(MW)	308.215	202.679	170.734	200.615
P_{G10}(MW)	187.234	237.412	217.616	191.052
P_{G11}(MW)	138.472	196.742	198.172	187.214
P_{G12}(MW)	595.893	577.398	585.870	600.000
P_{G13}(MW)	198.449	193.592	197.868	200.000
P_{G14} (MW)	88.886	92.923	93.217	100.000
P_{G15}(MW)	87.967	89.296	91.963	100.000
Production cost ($/h)	19880.225	19707.709	19668.944	19715.345
Emission (Ton/h)	00.705	00.780	00.673	00.678
total cost($/h)	20850.763	20781.957	20596.032	20648.368
Line losses (MW)	19.200	18.700	17.100	18.897
Time (s)	10.980	11.552	09.179	11.260

Table 7: Comparatives results ACO, GA$_{Koridak}$ [10], PSO$_{Koridak}$ [10] and ABC$_{Souhil}$ [16].

	ACO	**GA**$_{Slimani}$ [15]	**PSO**$_{Slimani}$ [15]	**ABC** $_{Monmarche}$ [24]
P_{G1}(MW)	242.89	266.850	270.899	180.899
P_{G2}(MW)	95.050	100.000	87.202	85.194
P_{G3}(MW)	138.89	140.000	172.766	180.765
P_{G6}(MW)	97.840	100.000	98.994	99.670
P_{G8}(MW)	311.02	280.438	255.877	270.274
P_{G9}(MW)	97.840	100.000	165.046	150.294
P_{G12}(MW)	285.10	281.875	62.134	65.008
P_L(MW)	17.960	18.400	16.200	618.100
Total cost($/h)	3171.785	3172.202	3210.115	3208.128
Time(s)	6.910	5.820	4.230	5.460

The AG presents the best cost of production of 807.200 $/h comparative survey, we noticed a difference of 1.56 % in relation to ACO. The ACO presents the weakest rate of 0.269 ton/h emision; either a difference of the order of 0.67 % comparative to ABC. With regard to the on line losses, ABC presents the most reduced value of 6.726 MW opposite to 6.929MW for ACO, either difference of 2.9%. While being interested in the total cost, ACO presents even best total cost with a value of 968.330 $/h.

Because the objective has been to reduce the cost of production and emission simultaneously and that ACO does a better economic and environmental optimization by AG report, PSO, and ABC we present results of programming the algorithm of the ant colony with parameters of another bigger network that the network IEEE-30 nodes like the Algerian network (15 generators).

Within sight of the results of the table above, being the emission, production costs, total emission, on-line losses and the computing time, we can say that ACO has the best results than other methods. The following table has the results of the algorithm of the colony of ants at the network IEEE-57 nodes compared with the Algerian network 59 nodes and we will compare with GA, PSO and ABC.

Table 8: Comparatives results ACO, **GA**$_{Slimani[15]}$, **PSO**$_{Slimani[15]}$ and **ABC** $_{Monmarche\ [24]}$.

	ACO	**GA**$_{Slimani[15]}$	**PSO**$_{Krishna\ murthy[21]}$	ABC$_{Boukti\ r\ et\ al[5]}$
P_{G1}(MW)	131.946	155.602	139.135	130.331
P_{G2}(MW)	56.830	49.929	55.552	58.234
P_{G5}(MW)	22.610	21.667	24.169	26.249
P_{G8}(MW)	34.370	29.986	35.000	35.000
P_{G11}(MW)	20.350	14.085	19.636	21.380
P_{G13}(MW)	24.220	20.255	17.104	18.929
Production cost ($/h)	819.996	807.200	813.899	820.166
Line losses(MW)	06.9269	06.9269	07.1953	06.726
Emission (Ton/h)	00.269	00.312	00.282	00.271
Total cost($/h)	968.330	979.079	978.185	978.511
Time (s)	06.368	05.128	03.589	04.630

In view of this table, the algorithm of the ant colony presents the weakest total cost of production with a longer calculation time.

Table 9: Comparative results ACO, **GA**$_{Slimani[15]}$, **PSO**$_{Mancer[11]}$ and **ABC**$_{Slimani[15]}$.

	ACO	**GA**$_{Slimani}$ [15]	**PSO**$_{Mancer}$ [11]	**ABC**$_{Slimani}$ [15]
P_{G1}(MW)	64.010	70.573	51.114	27.312
P_{G2}(MW)	22.750	56.570	64.726	19.546
P_{G3}(MW)	82.370	89.270	266.120	255.592
P_{G4}(MW)	46.210	78.220	397.877	63.550
P_{G5}(MW)	10.010	11.060	70.985	88.822
P_{G6}(MW)	47.050	57.930	58.693	39.759

P$_{G7}$(MW)	65.560	39.550	75.909	25.047
P$_{G8}$ (MW)	39.550	46.400	31.980	15.924
P$_{G9}$(MW)	154.23	63.580	152.952	63.873
P$_{G10}$(MW)	202.36	211.580	191.677	35.062
P$_{L}$ (MW)	12.980	17.580	13.620	19.650
Total cost($/h)	1815.7	1937.100	4372460.33	3740686.34
Time(s)	09.830	09.380	09.210	09.350

From this table, it is found that the algorithm of the present ant colony is the most optimal results on all parameters. In fact, the algorithm of the ant colony proves to be more efficient for the electrical networks of big sizes in relation to electrical networks of small sizes.

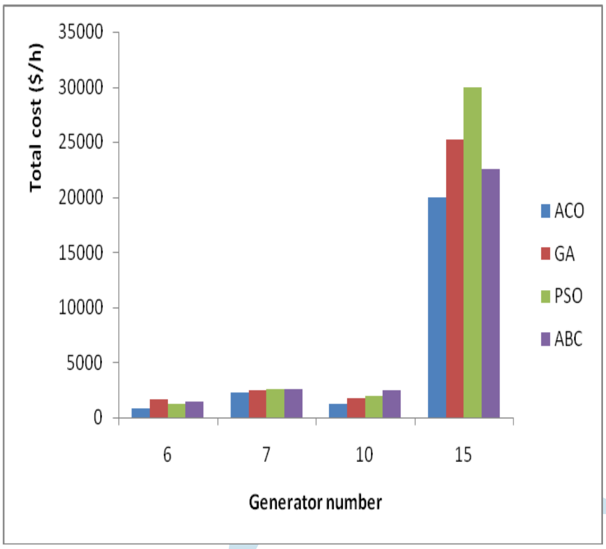

Figure 2: Cost according to the size of the network for ACO, GA, PSO and ABC.

From figure 2 which represents total cost according to the size of the network for ACO, GA, PSO and ABC; we can say that either the size of the network, the method of the ant colony presents best economic and environmental optimization.

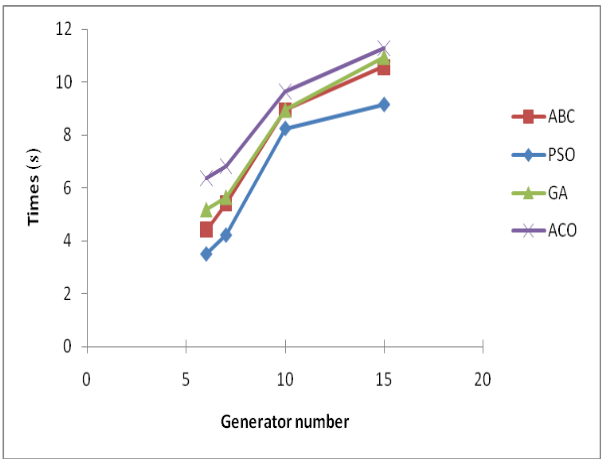

Figure 3: Time of convergence according to the size of the network for ACO, GA, PSO and ABC.

The figure above which represents the calculation time according to the size of the network for ACO, GA, PSO and ABC shows us that it is from the ten units of production that the algorithm of the ant colony begins to have the best time of convergence in relation to the other methods.

4. Conclusion

This study that was based on the strategy of optimization of a multi-electric energy power station source had as objectives the optimal power calculation for costs of production, minimal emission and the calculation of online power losses. To do this, we limited the study to the thermal generators and first applied it to network IEE-30 nodes, then to the network IEE-57 nodes (7 generators) and finally to Algerian networks 59 nodes (10 generators) and 114 nodes. We used the software MATLAB to program the algorithm of the ant colony in order to minimize the multi - objective function to know costs of production and emission while taking account the different constraints of equality and inequality. We obtained for the IEE network 30 nodes, the cost of production, emissions, total and on line losses of 819.996 $/h, 0.269 ton/h and 968.330$/h respectively as results. For the Algerian network 114 nodes, we got costs of production, of emissions, total and online losses of 19668.944$/h, 0.673 ton/h, 20596.032 $/h respectively and 17.1 MW with a time of 9.18 seconds. These results were compared to results gotten by other methods as the genetic algorithm, swarms of particle, and the algorithm of the bee colony. It resorts that no matter the size of the network, ACO does the best economic and environmental optimization on the one hand from networks of 10 generators and on the other hand the best time of convergence. We can say that ACO is a very efficient optimization method for networks of large size. The algorithm of the ant colony converges towards a minimum. To improve this work, it would be interesting to lead studies on the hybridization of the algorithm of the ant colony with a local research method in order to reduce the time of calculation and to apply the algorithm of the ant colony on the interconnected networks of Cameroon in order to optimize these.

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