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Theme:

optimization of Economic and environmental function through method of genetic Algorithms under the effect of the location of photovoltalic production in the electrical networks

Defended before the jury composed of :

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DEDICACE

To the man of my life, my eternal example, my moral support and source of joy and happiness, the one who always sacrificed himself to see me succeed, may God bless you my father.

In the light of my days, the source of tenderness, the example of devotion, the flame of my heart, my life and my happiness; mom whom I adore.

To the people whose presence I really enjoyed, to all my brothers and sisters, I dedicate this work, the great pleasure of which goes to them first and foremost for their advice, help and encouragement.

To the people who always helped and encouraged me, who were always by my side, and who accompanied me during my study journey, kind friends and all my study colleagues.

TAREK

IMAN

THANKS

This work. Above all, we thank Allah Almighty for giving me the health and strength to accomplish

The time has come to express all my gratitude to the supervisor Mr. Gadoume Abdelatif , assistant professor at Kasdi Merbah Ouargla University, for having agreed to direct this work, for the valuable advice that they have continued to provide me with. throughout the completion of this work as well as for its daily availability.

Our gratitude to all the people who gave us their support from near or far for the production, for their advice, without forgetting all the teachers, the support staff.

We also send all our wishes for success to our colleagues at the University of Ouargla

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Chapter III : Application and Results

Symbole

- **P** Doped Positive.
- **N** Doped Negative.
- **I** electric current.
- **VPV** Panel voltage.
- **VT** Thermal tension.
- **T** Absolute temperature in °K.
- **ID** Diode saturation current.
- **IPh** Photo current.
- **Has** The ideality factor.
- **K** Boltzmann's constant .
- **q** charge of the electron.
- **IPh** Current photo created by the cell.
- **Pch** Shipping order value
- **I0** Diode current.
- **RSH** Shunt resistors.
- **RS** Series resistance.
- **TC** junction temperature (K).
- **Fthi (PG**i) The fuel cost function.
- **Fpvj(Ppvj)** is the function of the cost of the min-photovoltaic power plant.
- **PGi** The power generated.
- **Ppvj** The power generated by the farm at node j.
- **Ai, Bi, Ci** The coefficients of the global function.
- **ɑi, bi, ci** cost coefficients.
- **Ng** Total number of generators.
- **nf** Total number of min-photovoltaic power plants.
- **dj** The cost coefficient specific to the photovoltaic min-power plant.
- **Pd** Total active load power.
- **PL** Total active losses in the network.
- **PGi min** Minimum active power of the generator.
- **PGi max** Maximum active power of the generator.
- **FP** price penalty factor

- **ED** Environmental Economic Dispatch
- **Bij** the coefficients of Losses
- **B00** Constant factor.
- **B0i** variable linear factor
- **AG** Genetic Algorithm
- **ND** the number of consumer nodes.
- **FSA** Fast harmony search algorithm

Resume

The present study focuses on the optimization of economic and environmental dispatching in an electricity network comprising two thermal power stations and one hydroelectric station Economic and environmental dispatching involves the optimization of the production cost function and the function of toxic gas emissions in electrical networks. The research investigates two scenarios: one involving conventional production in the electricity network, and the other incorporating photovoltaic production. The optimization process is conducted using the genetic algorithm method within the Matlab environment. The results demonstrate the significant impact of integrating photovoltaic production, leading to reduced electricity production costs and minimized toxic emissions. Key terms relevant to this study include centralized and decentralized production, economic and environmental dispatching, optimization, and genetic algorithms.

La présente étude porte sur l'optimisation du dispatching économique et environnemental dans un réseau électrique comprenant deux centrales thermiques et une centrale hydroélectrique. Le dispatching économique et environnemental passe par l'optimisation de la fonction coût de production et de la fonction des émissions de gaz toxiques dans les réseaux électriques. La recherche étudie deux scénarios : l'un impliquant une production conventionnelle sur le réseau électrique et l'autre intégrant une production photovoltaïque. Le processus d'optimisation est mené à l'aide de la méthode de l'algorithme génétique dans l'environnement Matlab. Les résultats démontrent l'impact significatif de l'intégration de la production photovoltaïque, conduisant à une réduction des coûts de production d'électricité et à une minimisation des émissions toxiques. Les termes clés pertinents pour cette étude incluent la production centralisée et décentralisée, la répartition économique et environnementale, l'optimisation et les algorithmes génétiques.

تركز الدراسة الحالية على تحسين التوزيع الاقتصادي والبيئي في شبكة الكهرباء التي تضم محطتين للطاقة الحرارية ومحطة كهرومائية واحدة. يتضمن التوزيع الاقتصادي والبيئي تحسين وظيفة تكلفة إنتاج ووظيفة انبعاثات الغازات السامة في الشبكات الكهربائية يبحث البحث في سيناريوهين: أول يتضمن إنتاج التقليدي في شبكة الكهرباء، وآخر يتضمن انتاج الكهروضوئي تتم عملية التحسين باستخدام طريقة الخوارزمية الجينية داخل بيئة ماتالاب. وتوضح النتائج التأثير الكبير لتكامل إنتاج الطاقة الكهروضوئية، مما يؤدي إلى خفض تكاليف إنتاج الكهرباء وتقليل النبعاثات السامة. تشمل المصطلحات الرئيسية ذات الصلة بهذه الدراسة إلنتاج المركزي والالمركزي والتوزيع الاقتصادي والبيئي، .والتحسين، والخوارزميات الجينية

General Introduction

General Introduction

The growing global population and the resurgence of agriculture and industry have heightened the importance of electric power in modern economies and daily life. This has led to a continuous rise in electrical energy consumption, motivating scientists and engineers to develop methods and computational tools that optimize electrical energy usage efficiently while maintaining quality standards and minimizing costs. Due to the non-storable nature of electrical energy, a constant balance between production and consumption is necessary. This often results in an increase in the number of power plants and associated infrastructure, leading to higher costs and environmental degradation.[2][3]

Simultaneously, the renewable energy market has expanded significantly, leading many countries to revise their development policies in favor of sustainable and eco-friendly energy sources. Photovoltaic (PV) energy has become a crucial component of this shift towards cleaner energy. Integrating PV production into electricity networks is expected to significantly impact the economic and environmental dispatching of these networks.

The primary goal of this thesis is to optimize the economic and environmental dispatching of an electricity network that includes photovoltaic production using the genetic algorithm method. This method is well-regarded for its effectiveness in optimizing complex systems. The thesis is organized into three chapters. Starting with the definition of electricity grids and power generation, through cost functions and emissions, to the operational constraints and various optimization techniques . The second chapter deals with the exposition of optimization methods, particularly highlighting the genetic algorithm approach. The third and final chapter focuses on the application of genetic algorithms for the economic and environmental optimization of an electrical network. It compares without decentralized production and with the integration of photovoltaic production in the electricity production chain The work concludes with a general summary of the results obtained.[14]

Chapter I :Economic and environmental dispating of

electrical networks

I.1 Introduction

Exploitation of electrical appliances using a number of problems using the ordre technique and economic. Programs with content developed by experts are guaranteed at all times and To cover the energy demand, you must ensure that the quality is acceptable for the purchase.Delivery and delivery of a security system are as high as possible. The ability to store energy in a large environment is indispensable. Maintenance of all instant equipment into production and consumption with minimization.

The production units and gas toxic emissions are based on the optimal delivery process. It is called economic and environmental dispatching.

I.2 Basic concepts [2][3[4]

I.2.1 Electrical grids and prodauction of electrical energy

An electrical network is a collection of mechanisms for transmitting electricity. Electricity travels from where it is generated to where it is used. The primary function of an electrical network is to deliver active and reactive electricity as needed by the different devices linked to it. Transmission lines connect the production and consuming sites [5].

Indeed, because electrical energy cannot be realistically stored, the generators' output must always be precisely suited to consumption, so that when demand varies, the generators must react to preserve this equilibrium [5]

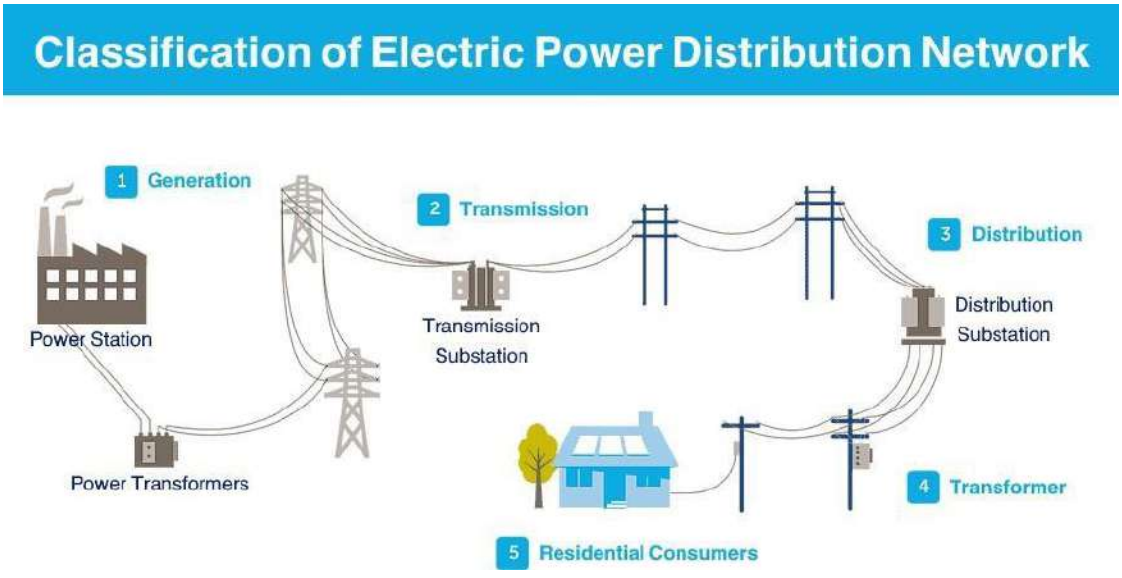


Figure 11 classifition of electric power distribution network

For electrical energy to be usable, the network must meet the following requirements:

- Ensure the customer has the power they need
- Provide energy at an acceptable price;
- Maintain rigorous safety standards

Ensure environmental protection;

In a very generic way, an electricity network is always composed of four major parts.

I.2.1 ,a production of electrical energy

It is the generation of all the powers consumed by the entire network, inIn the vast majority of cases, voltages are produced in the form of a three-phase system.via. Alternators are driven by various types of so-called primary energy sources .

I .2.2.Production methods

A means of producing electrical energy is defined as any installation capable of to convert a primary energy source into electrical energy that can be injected into a network.

Electricity production plants generally use coal, Oil and gas (conventional thermal power plants) or enriched uranium (power plants).Nuclear (which does not exist in Algeria) to produce the initial heat. Most have a capacity of between 200 MW and 2000 MW is needed in order to achieve cost savings.

Large installations (in Algeria, the most powerful group is a combined cycle at the level). of the SKS power plant with a power of 412.5 MW (located in Skikda).

I.2.2.1 Thermal power plant

Fossil fuels: coal, oil, and natural gas are burned to create heat. The heat is used to boil water, which creates steam. The steam spins a turbine, which turns a generator to produce electricity. This is the most common way to produce electricity in the world, but it also produces the most greenhouse gases.

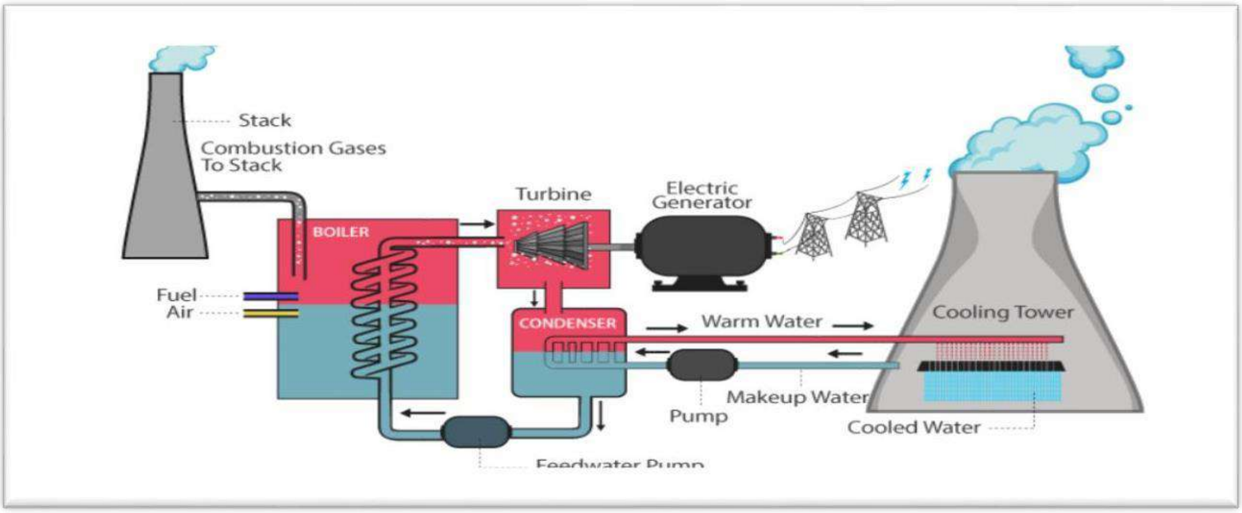


Figure 2thermal power plant

I.2.2.2 <u>Hydropower</u>:

Moving water, such as from a river or waterfall, rotates a turbine, generating energy. Hydropower is a clean and sustainable energy source, yet it may have a tremendous influence on the ecosystem surrounding dams.

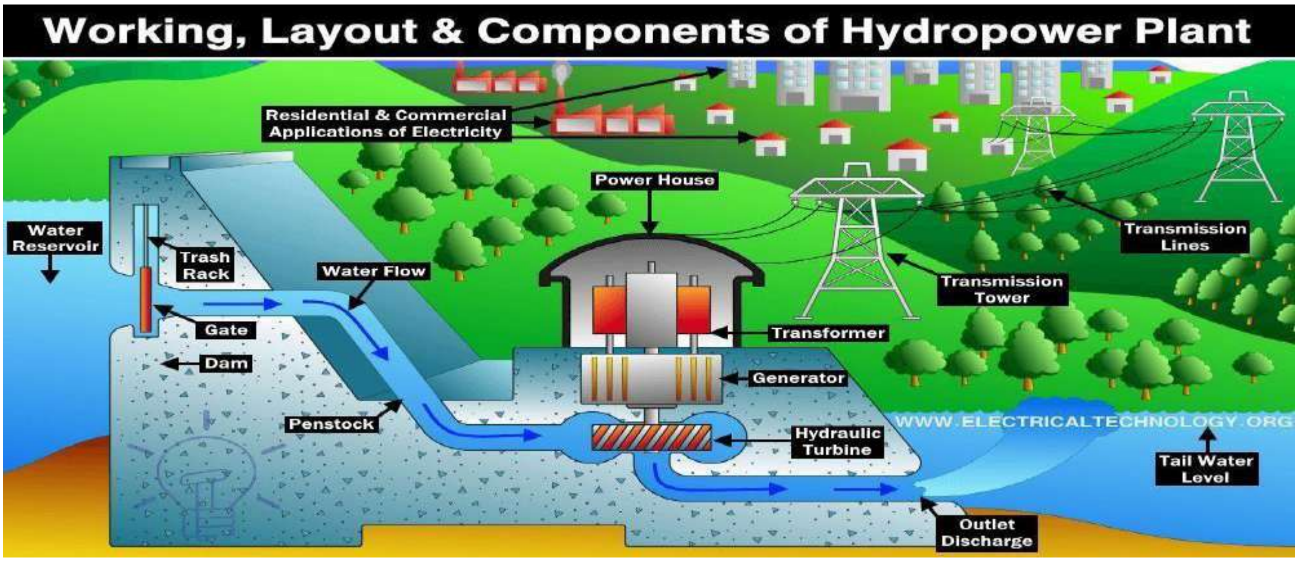


Figure I.3 lyout &components of hydropower plant

I.2.2.3 Nuclear power

Nuclear power generates heat through nuclear fission. Nuclear fission is the process of breaking an atom's nucleus, which produces enormous amounts of energy. Heat is used to boil water, producing steam. The steam moves a turbine, which then turns a generator to generate energy. Nuclear power is a clean source of electricity, but it creates radioactive waste and poses the danger of nuclear accidents.

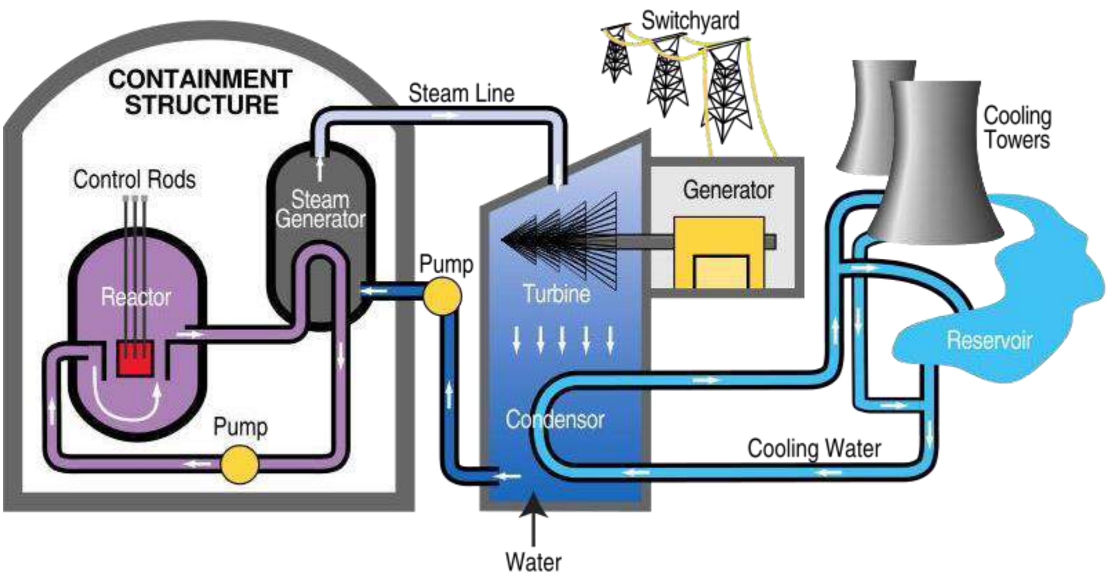


Figure I.4Nuclear power

I.2.24 Solar Panels

The photons are converted into electric current by a semiconductor. Photovoltaic solar energy refers to electricity produced by transforming part of solar radiation with a photovoltaic cell. Several cells are connected and form a photovoltaic solar panel (or module). Several modules that are grouped in a photovoltaic solar power plant are called a photovoltaic field.

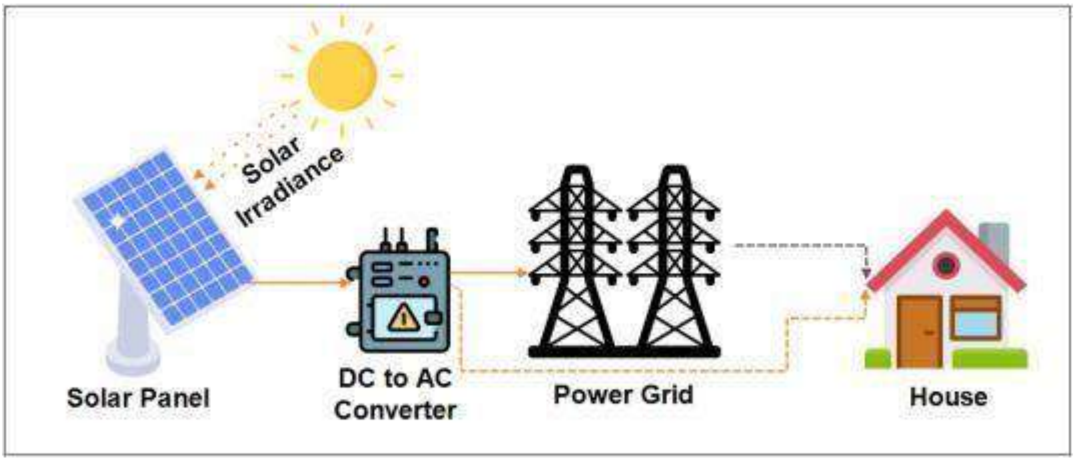


Figure I.5Principle of photovoltalic system

I.2.2.4 Wind power

It is produced by the force of the wind, which turns the blades of a wind turbine. So-called mechanical energy is converted into electrical energy by a generator.

A wind turbine is a machine that converts the kinetic energy of the wind into wind-type mechanical energy This mechanical wind energy has been used throughout the ages to pump water or grind grain [6]. Current machines are used to produce wind-type electricity, which is consumed locally (isolated sites) or injected into the electricity network (wind turbines connected to the network).

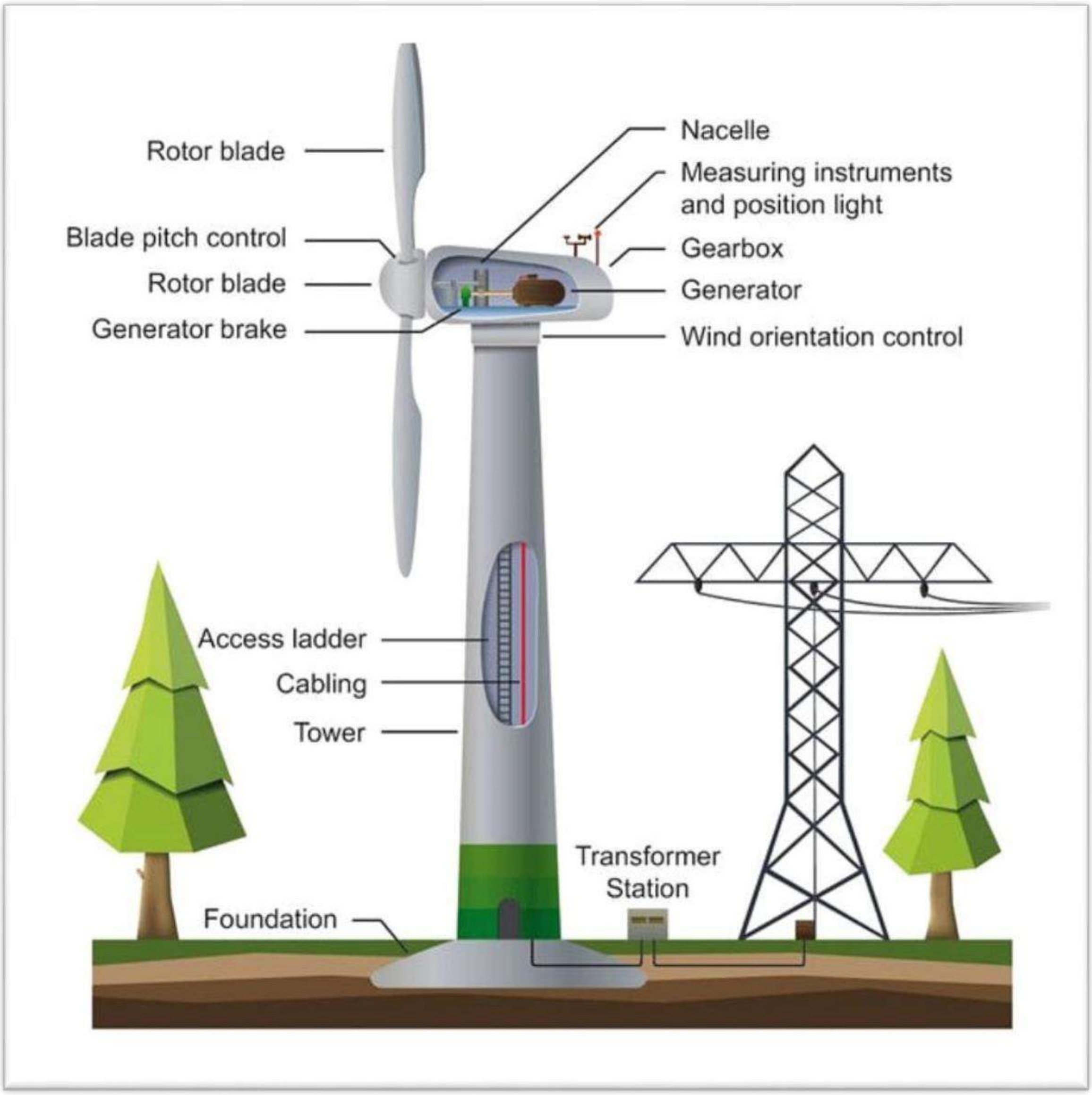


Figure I.6Wind power

I,2,2.6 Biomass energy

It is a renewable energy source that comes from organic matter, like plants, animals, and even waste products. This organic matter captures the sun's energy through photosynthesis and stores it in chemical bonds. When we burn biomass, we release that stored energy. There are a number of different types of biomass that can be used for energy production. The most common type is wood, but biomass can also include crops, agricultural residues, food waste, and yard waste. Biomass can be burned directly to produce heat, or it can be converted into other forms of energy, such as electricity, transportation fuels, and biogas.

Biomass is a carbon-neutral energy source, which means that it does not release any new carbon dioxide into the atmosphere when it is used. This is because the plants that are used to produce biomass absorb carbon dioxide from the atmosphere as they grow. When the biomass is burned, the carbon dioxide that is released is the same carbon dioxide that was absorbed by the plants. However, there are some concerns about the sustainability of biomass energy. For example, if we burn too much biomass, it could lead to deforestation and other environmental problems.

Figure I. 7Biomass energy

I.2.2 Transportation

It consists of routing the power produced by the production units to the consumption points. Therefore, the main role of the transport network is the connection between the major consumption centers (large consumers and distributors) and the means of production.

This role is particularly important because of the storage of electrical energy. almost impossible.

Large power plants are often near streams and oceans, around rivers. On an economic level, the order of magnitude of the distances imposes, among other things, the fact of conveying electrical energy in alternating current under very high voltage in order to minimize losses at the level of transmission lines, unlike production and consumption, which occur at lower voltage levels. Transformers are then necessary for voltage upgrading [2].

Large power plants are often near streams and oceans, around rivers. On an economic level, the order of magnitude of the distances imposes, among other things, the fact of conveying electrical energy in alternating current under very high voltage in order to minimize losses at the level of transmission lines, unlike production and consumption, which occur at lower voltage levels. Transformers are then necessary for voltage upgrading [2].

Electricity transmission networks are made up of lines (or line corridors). connecting the different busbars or nodes. Generally speaking, they have a topology. meshed to offer a multiplicity of possibilities to go from one node to another in the network. Transmission networks must be operated within operating limits as authorized. These limits, or, in other words, the constraints of the network, are expressed by values. (maximum or minimum) on certain network variables (power flow on the lines, transformers, voltage level, etc.).

In the event that these limits are exceeded several times, this implies a degradation of the different components of the system, and the network risks falling into an instability problem.

I.2.3. The distribution

Distribution is ensured at medium voltage (MV) and low voltage (LV), and even at high voltage for HT customers. The distribution is adapted according to the type of consumption of very large factories, which can be supplied directly from high-voltage network according to the maximum power requested MPR (in the case of the Bni Haroun dam in Algeria, powered by the 60 KV network, its MPR is 100 MW) or residential buildings, schools, etc. at low voltage (in Algeria, 220 to 380 V).

I.2.4. The consumption

It is the point of arrival in an electrical network. Electricity consumption corresponds to an active power call on the network for a period of time. determined This corresponds to energy consumption. Electricity is consumed.

by different types of consumers (residential, commercial, and industrial). There Electricity consumption is characterized by:

- its strong fluctuations.
- the difficulty of predicting it accurately.

I.3 Function of production cost

Production costs represent all expenses incurred by companies in order to achieve their production goals. They depend on the factors of production used . A power plant's production cost is often described as a second-degree polynomial in PG (active power produced), with plant-specific constants .The cout function is a second-order polynomial in terms of PGi that takes the following form:

$$F_T = \sum_{i=1}^{ng} (a_i P_i^2 + b_i P_{Gi}^2 + \ )_i \qquad \textbf{(I.1)}$$

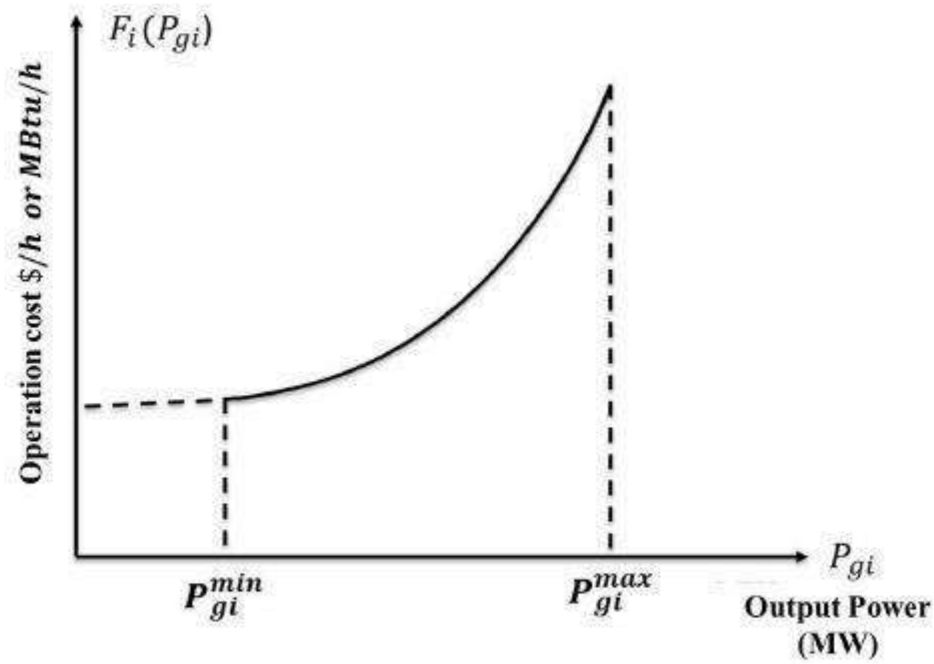


Figure I.8Input-output characteristic of a production unit

where :

a_i $b_i$and c_i are constants specific to each plant.[8]

The constant ai is normally called idle cost and represents the cost for keep a zero-production generation unit started.

P_{Gi}: active power generated per generation unit (i).

Fi (P_{Gi}): the cost function of the power plant (i).

Ng: number of generators

It is very important to note that other specific characteristics must be taken into account when considering the cost of electricity production. This is particularly the case with cost. specific to start or stop the production unit (cost of starting and stopping), at For example, the start-up cost corresponds to the cost of the energy required to put into operation all the auxiliaries allowing the production of electricity (boilers, pumps, etc.).

This cost normally depends on the state of the production unit at the time of the call for assistance. start (cold or hot start) and start time (peak or trough). THE Technical constraints are also important for operation. Generally, the unit of production can only operate stably at a certain production level. Minimal (minimum production capacity) and up to a maximum production level Maximum production capacity[7][2].

I.4 Minimizing generation costs [9]

The primary purpose of economic dispatching is to reduce production costs. As a result, each generator accounts for the entire cost. On the other hand, we are well aware that the cost-influencing elements may be characterized in three ways. Key elements are the generators' operational efficiency, fuel costs, and transmission line losses. And, to reduce the cost function, we can change one of the earlier points. This minimizing translates into the following condition:

$$Min\ (F_T) = Min\ (\sum_{i=1}^{Ng} Fi(P_{Gi})) \text{ with } F = \sum_{i=1}^{Ng} Fi(P_{Gi}) \quad \textbf{(I.2)}$$

(Ng): the number of generators.

F: The total cost function of production

I.5 Definition of constraints

Defines conditions on the state space that variables must satisfy. These These constraints are often constraints of inequality or equality and generally make it possible to limit the search space

I.5.1 Constraints of equality

This is the equation of power flow in balance between generation and request, expressed by the following formula:

$$\sum_{i=1}^{Ng} PGi - \quad - P_D \; P_L = 0$$

Where

$$P_D = \sum_{i=1}^{ND} P_{Di} \qquad \textbf{(I.3)}$$

PD :is the total active power absorbed by the entire load.

PDi is the active power absorbed by the load (i).

PL: active losses in transmission linens

ND: the number of consumer nodes.

According to this expression, we can say that the electrical energy system is in equilibrium because the sum of active powers generated and powers consumed by the total load And the active loss on the lines is zero .

I.5.2 Inequality constraints

They are also called security constraints, directly linked to the limits associated with Power stations.

$$P_{Gim} \leq PGi \leq P_{GiM}$$

Where :

P_{Gi}^{M}: The maximum active power generated by the generator (i).

P_{Gi}^{m}: the minimum active power generated by the generator (I).

I.6 Transmission losses

Transmission losses: This is the difference between generated and distributed units. Those- These losses are divided into technical losses and non-technical or commercial losses. The loss These techniques are due to the energy dissipated in the conductors and equipment used in the transmission lines and magnetic losses in transformers.

$$P_L = \sum_{i=1}^{ng} \sum_{j=1}^{ng} P_i \; B_{ij} P_j + \sum_{i=1}^{ng} B_{0i} \, P_i + \; B_{00} \qquad \textbf{(I.4)}$$

B_{ij}, B_{0i} and **B_{00}**: are the loss coefficients or B-coefficients.

B_{0i}: variable linear factor.

B_{00}: constant factor.

B-coefficients, also called loss coefficients, are assumed to be constant for a basic range of loads, and reasonable accuracy is expected when operating conditions The actual operation is close to the base-case conditions used to calculate the coefficients. They are generally represented by Bij.

I.7- Minimizing gas emissions

Emissions of toxic gases released by thermal generation units due to the combustion of fossil fuels, such as **CO_2.** And **NO_x** can individually contribute to the Minimization of overall emissions through:

I.7.1. CO2 minimization

It is done by minimizing the expression relating to the CO2 emission expressed in tons/h.

$$E_{co2}\left(P_{i,i}\right) = \sum_{t=1}^{T} \sum_{i=1}^{Ng} e_{co2\ fi}\ \left(p_{i,t}\right) I_{i,t} \qquad \textbf{(I.5)}$$

or

$$e_{co2\ fi}\left(P_{i,t}\right) = \left(\alpha_{co2\ i} + \beta_{co2\ i}\ P_{i,t} + \delta_{co2\ \ xi} P_{i,t}^{2}\right) \quad \textbf{(I.6)}$$

The CO2 emission function Of the generation units i and αi, βi, and δi CO2 emission coefficients

I.7.2 Minimizing NOx

It is done by minimizing the expression relating to the CO2 emission expressed in tons/h.

$$E_{NOX}\left(P_{i,i}\right) = \sum_{t=1}^{T} \sum_{i=1}^{Ng} e_{NOx\ fi}\ \left(p_{i,t}\right) I_{i,t} \qquad \textbf{(I.7)}$$

or

$$e_{NO\ x\ fi}\left(P_{i,t}\right) = \left(\alpha_{NO\ xi} + \beta_{NO\ x\ i}\ P_{i,t} + \delta_{NO\ xi} P_{i,t}^{2}\right) \quad \textbf{(I.8)}$$

The NOx emission function of the generation units I and αI, βi, δi NOx emission coefficients

I.8. Optimisation bi-objective and single-objective

Single-objective

Single-objective optimization focuses on one objective at a time. ByFor example, this may consist of minimizing the cost of electricity production.without considering other factors like gas emissions or reliability.of the network. In this context, the objective is to identify the solution thatoptimizes this single criterion.

bi-objective

Bi-objective optimization makes it possible to find a compromise betweenoften opposing objectives, such as economic performance and impact.environmental, providing a series of optimal solutions. TheseSolutions help decision-makers make informed decisions in thenetwork management

I.9. Conclusion

In this chapter, we discuss notions of economic and environmental dispatching in electrical networks. We explored the importance of electrical networks in electricity generation, highlighting the role of production costs and associated constraints. Additionally, we discussed transmission losses and the impact of toxic gas emissions on the environment. To ensure effective and sustainable operation of electrical networks, it is essential to simultaneously consider both economic and environmental aspects, seeking solutions that reduce production costs and environmental impacts.

Chapter II: Economic

and

environmental dispatching of electricity networks and

optimization methods

II.1 Introdution

Environmental Economic Dispatching (EED) is an essential operation in energy transmission systems, driven by increased electricity consumption due to population growth, urbanization, and industrialization. This increase in demand for electricity requires an increase in production, often achieved by fossil-fuel thermal plants. However, this increase in production leads to higher production costs due to high fuel prices and CO2 emissions, thereby contributing to environmental problems such as global warming.

Environmental economic dispatching aims to solve these problems by efficiently distributing the power generated by power plants to reduce both total production costs and CO2 emissions. DEE is a crucial tool for the optimum economic and environmental operation of the power grid .

II.2 The objective of Electrical Networks' Economic and Environmental Dispatching

Taking care of these environmental and economic issues is the aim of economic and environmental dispatch. In order to lower overall production costs and CO2 emissions[11], DEE entails the strategic distribution of power produced by all power plants . As such, it functions as a basic and vital instrument for the electrical network's best possible economic and ecological performance.

Dispatching can be divided into two categories: dynamic economic and environmental dispatch, which resolves the issue across time (e.g., a day), and static economic and environmental dispatch, which solves the problem for a single demand at a certain time.

II.3 Optimiztion of economic and environmental dispatching

Economic and environmental dispatching is a multi-purpose optimization problem involving competing objectives such as minimizing production costs and minimization of emissions . It therefore requires a rigorous mathematical formulation

II.3.1 Formation of an optimization problem :

The definition of an optimization problem is to find the minimum or maximum (the optimal) of a given unction. The minimum or maximum of several objective functions must thus be found in order to solve an optimization issue like the DEES and DEED. These functions provide variables for making decisions that are subject to limitations that establish the problem's complexity Mathematical models are sometimes used to represent the elements to be optimized. Optimization methods then use these models to solve problems. An optimization problem is represented by one or more objective functions and constraints [12]. Mathematically, an optimization problem will take the following form Minimizer:[13]

$\vec{f}(\vec{x})$ **(function to be optimized)**

With $\vec{g}(\vec{x}) \leq 0$ **(m inequality constraints)**

And $\vec{h}(\vec{x}) \leq 0$ **(m equality constraints)**

The number, nature and type of f(x), g(x), h(x) or the search space make it possible to classify optimization problems [13].

Depending on the number of objectives, we will distinguish two categories of optimization problems: single-objective problems (k = 1) and multi-objective problems (k > 1). Multi-objective optimization is also called multi-criteria optimization [12].

II.4 optimization Techniques

Numerous algorithms have been used in the literature to solve the economic and environmental dispatching optimization problems. These methods vary and are distinguished by their guiding principles, approaches, and outcomes.

Based on these differences, these methods can be grouped into two main classes: stochastic methods and determinist methods.

A general classification of optimization methods [11] is presented in Figure II.1.

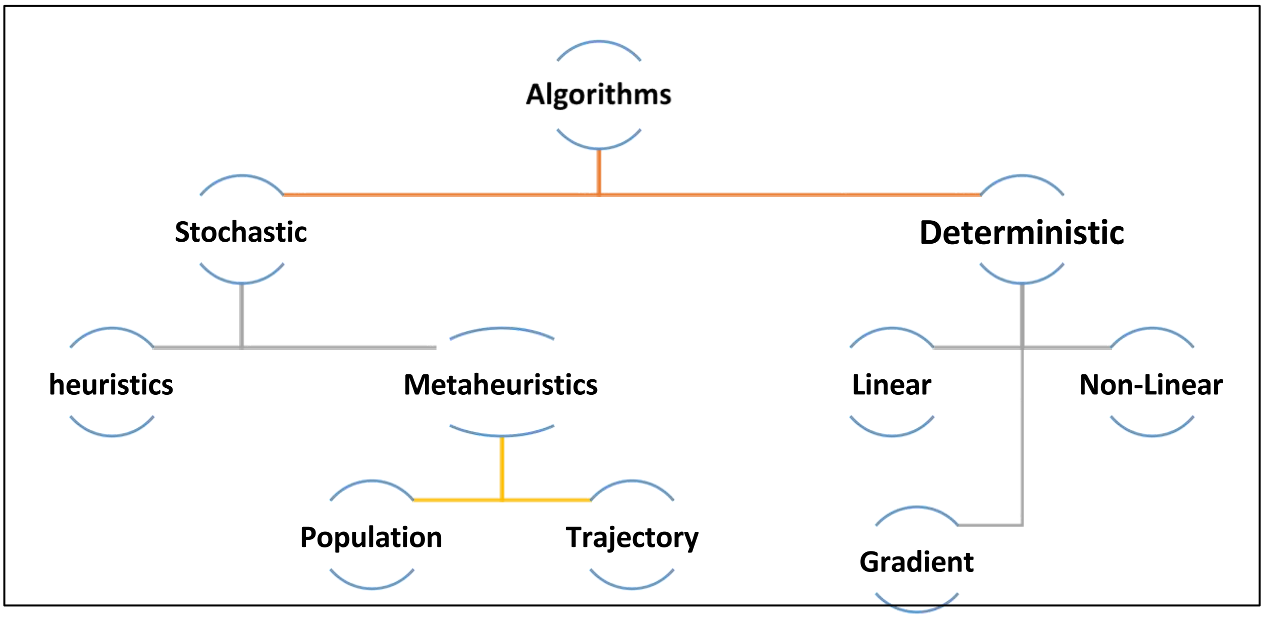


Figure **IIClassification of optimization methods ithmes conetic heuristics**

II.5 Genetic Algorithms

Genetic algorithms (AG) are stochastic optimization techniques inspired by the mechanisms of natural evolution and genetics. They were introduced in the 1970s by John Holland and are widely used in various areas to solve optimization problems.

AGs operate by manipulating a population of potential solutions (called individuals or chromosomes) using genetic operators such as selection, crossing, and mutation. These operators enable new solutions to be generated by combining and modifying existing solutions in order to find the best possible solution to a given problem.[14]

AGs are suited to solving multi-purpose optimization problems, where it is necessary to find a compromise between several contradictory objectives. By adjusting the parameters of the AGs such as population size, probabilities of crossing and mutation, one can influence the performance of the algorithm and its ability to find quality solutions.

II.5.1. purpose of genetic algorithms

The goal of these genetic algorithms is to optimize a predefined function, called objective function, or fitness; they work on a set of candidate solutions, called a “population” of individuals or chromosomes (we will use individual or chromosome interchangeably). The latter are made up of a set of elements, called "genes", which can take several values, called "alleles". [30]

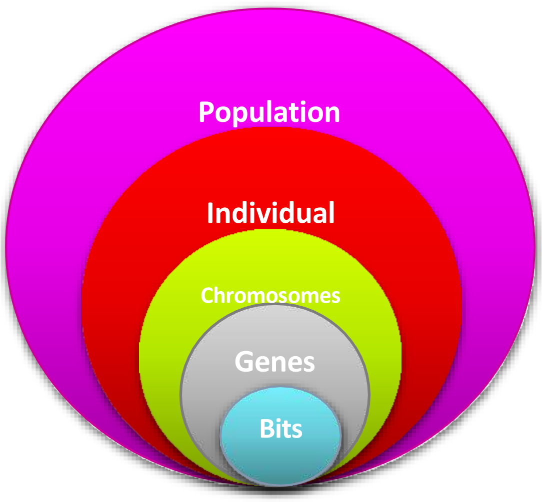


figure II 2. Levels of organization of AGs

II.6 The purpose of these genetic algorithms ; is to optimize a predefined function, called objective function, or fitness; they work on a set of candidate solutions, called a “population” of individuals or chromosomes (we will use individual or chromosome interchangeably). The latter are made up of a set of elements called "genes," which can take several values, called "alleles.”

II.7 Presentation of the AG

The following is the definition of genetic algorithms:

II.7.1 The main objective of the AGs is to find the best possible solution in terms of the objective function to be optimized, also called the fitness function. To do this, AGs typically follow a multi-stage process:

II.7.2 Initialization: An initial population of chromosomes is generated randomly.

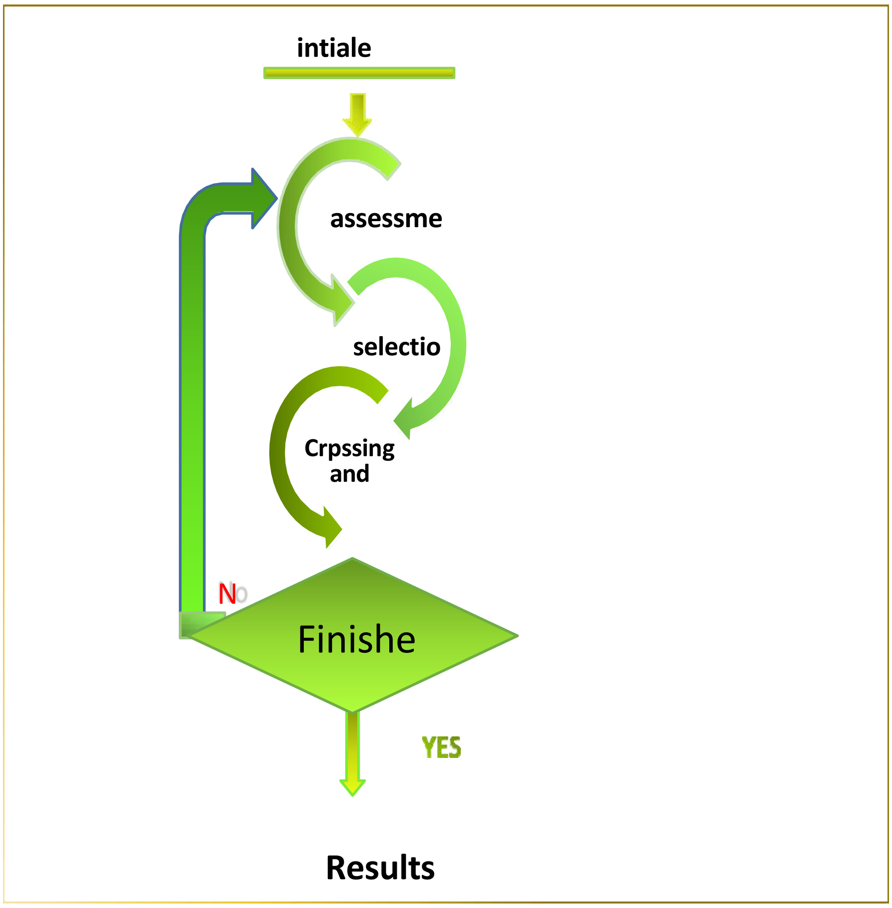
II.6.3 Evaluation: Each chromosome is decoded to obtain a concrete solution and then evaluated according to the fitness function.

II.7.4 Selection: A new population is created by selecting the most suitable individuals based on their performance in relation to the fitness function.

II.7.5 Reproduction: Cross and mutation operations are applied to selected individuals to generate new potential solutions.

This process of selection, reproduction, and evolution is repeated over several generations until a stop condition is reached, usually based on a predefined criterion such as the number of iterations or the achievement of a satisfactory level of performance.

AGs are widely used to solve complex and multi-purpose optimization problems in a variety of areas, offering an effective approach to finding quality solutions by exploring a research space in an adaptive and scalable way.



II 3.the flowchart of the genetic

II.8 The Operators

Genetic algorithms use different operators to guide the process of population evolution to potential solutions. The main operators used in genetic algorithms are:

II.8.1.1 Selection Operator: This operator determines which individuals in the current population will be selected for reproduction based on their performance relative to the fitness function. It enables the most adaptive individuals to survive and reproduce, thus promoting the overall improvement of the population.

The selection operator is one of the essential components of genetic algorithms. This operator determines which individuals from the current population will be chosen for reproduction, generally based on their performance relative to the fitness function. There are several selection methods used in genetic algorithms, including:

II.8.1.2. The Roulette Approach to Choosing : This is the most widely utilized and well-liked strategy. With this approach, every individual is picked in part on the basis of their performance; therefore, the more adaptively inclined they are, the more likely it is that.they.will.be.selected.

By applying the metaphor of the "roue du forain," it is believed that every individual possesses a sector whose angle corresponds to their degree of adaptability, or "fitness." The wheel is revolved, and when it stops, a sort is used to select the individual who corresponds to the given sector.

II.8.1.3. Roulette Selection: This method assigns to each individual in the population a probability of selection proportional to their performance (fitness). The most suitable individuals have a greater chance of being selected, thus simulating the principle of a roulette where the sectors are proportional to the fitness of each individual .

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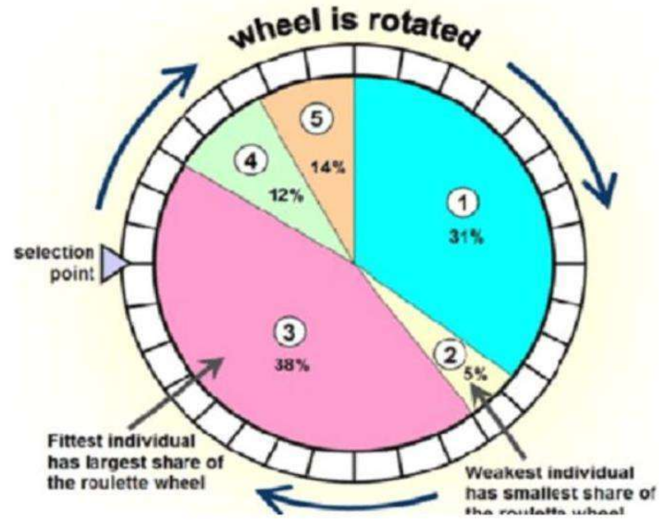


No.	Fitness	% of total
1	6.82	31
2	1.11	5
3	8.48	38
4	2.57	12
5	3.08	14
Total	22.05	100

Figure II 4 the biased lottery selection method

II.8.2.3. Elite Selection: This method consists of selecting the best individuals from the current population to include them directly in the next generation, thus ensuring the preservation of high-quality solutions.

II.8.2.4. Tournament Selection: In this method, tournaments are organized between randomly chosen individuals. The most successful individuals in each tournament are selected for reproduction.

II.8.2.5. Stochastic Universal Selection: This less common method consists of dividing a segment into equidistant sub-segments, each of which represents an individual. Individuals are selected based on random points in the segment.

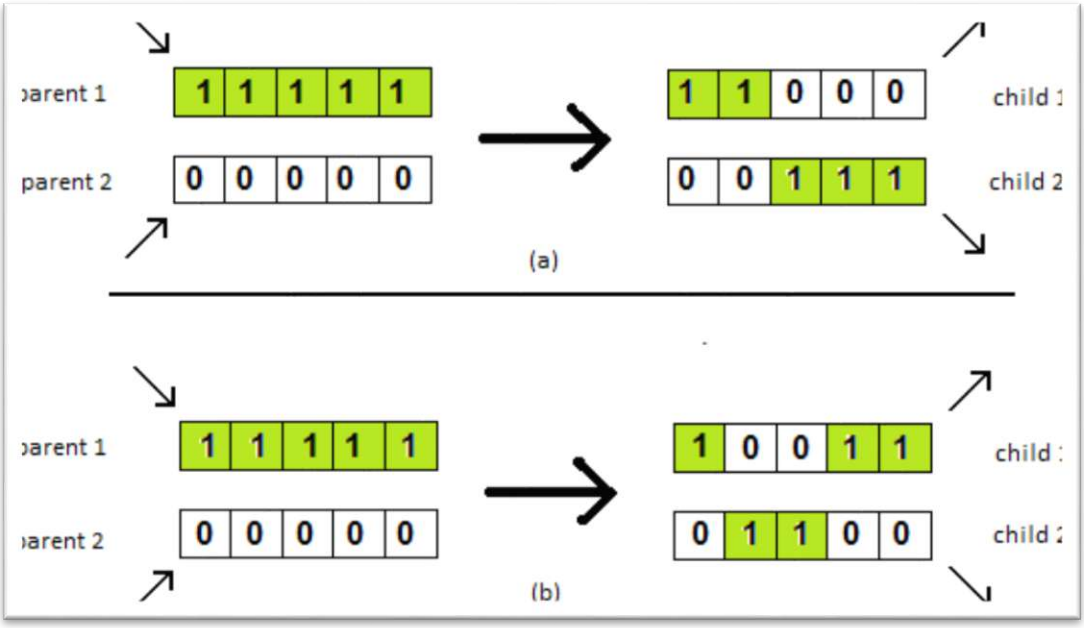
Each selection method has its advantages and disadvantages, and the choice of the appropriate method depends on the problem to be solved and the objectives of optimization. By effectively using the selection operator in combination with the cross and mutation operators, genetic algorithms can converge to high-quality solutions for a variety of optimization problems .

The crossover operator, also called the crossover, is a key element of genetic algorithms. This operator simulates the process of genetic recombination by taking two selected parent individuals and creating new individuals by combining some of their characteristics. The aim of the crossroads is to introduce diversity into the population and explore new potential solutions by combining genetic information from parents.

There are several types of crossing commonly used in genetic algorithms, including:

1. Cross point: In this type of cross, a cut point is chosen randomly on the chromosomes of the parents. The parts of the chromosomes located after the cut point are exchanged between the parents to create new individuals.

2. Two-point crossing: Similar to one-point intersection, but with two cutting points. The segments between the two cutting points are exchanged between the parents to create new individuals

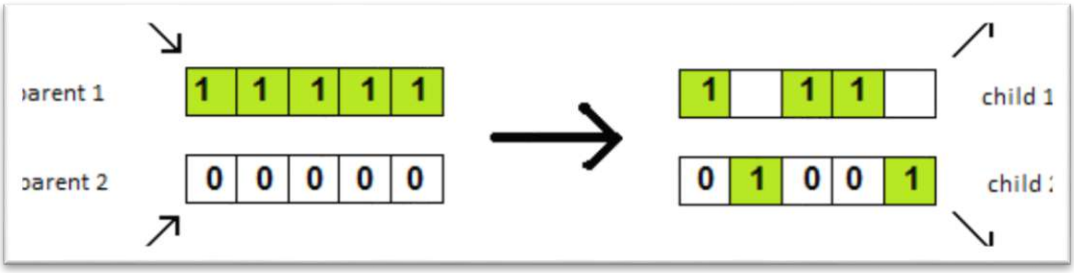


1Crossing in one crossover point, (b) Crossover in two points

3. Uniform crossing: Each gene of the parent is considered independently, and a gene is randomly chosen to be passed on to the offspring. This type of intersection introduces great diversity in the population.

The choice of the type of intersection depends on the problem to be solved and the structure of potential solutions. By wisely combining the cross-operator with the selection operator and the mutation operator, genetic algorithms can effectively explore the research space and converge towards high-quality solutions for complex optimization problems

In addition to selection, intersection, and mutation operators, genetic algorithms use other parameters that influence their effectiveness and their ability to find quality solutions. Here are some of these parameters:



II.8.3. Mutation Operator

The operator of mutation in genetic algorithms plays a crucial role in introducing diversity and maintaining genetic variability within the population of solutions. This operator is responsible for randomly changing the allele value of a gene with a very low probability, typically ranging between 0.01 and 0.001. Alternatively, the probability of mutation, denoted as pm, can be set as pm = 1 /lg, where *lg* represents the length of the bit string encoding the chromosome. A mutation operation typically involves the inversion of a single bit or multiple bits, although the latter is extremely rare due to the low probability of mutation. The specific bit to be inverted is chosen randomly at a particular locus. By randomly altering the characteristics of a solution, the mutation operator introduces randomness and perturbation into the population. This perturbation is essential for exploring new regions of the search space and preventing premature convergence to suboptimal solutions. In essence, the mutation operator acts as a disruptive element that injects variability and noise into the population, aiding in the exploration of the solution space and potentially leading to improved solutions

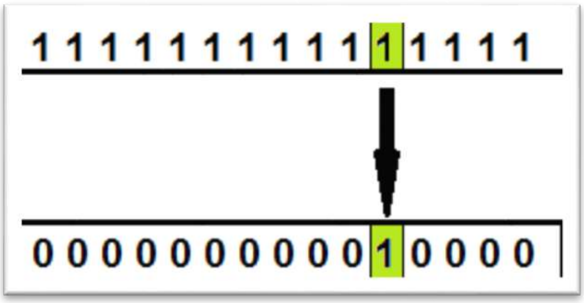


Figure II 7.The mutation in binary encoding

II.8.4. The Roulette Approach to Choosing

This is the most widely utilized and well-liked strategy. With this approach, every individual a People are picked in part on the basis of their performance, therefore the more adaptively inclined they are, the more likely it is that they will be selected.

By applying the metaphor of the "roue du forain," it is believed that every individual possesses a sector whose angle corresponds to their degree of adaptability, or "fitness." The wheel is revolved, and when it stops, a sort is used to select the individual who corresponds to the given sector.

II.8.5. Other Parameters

1. Population size (N): The size of the initial population in a genetic algorithm is a crucial parameter. A population too small can quickly converge towards an underoptimal solution, while a population too large can result in excessive calculation times. The choice of population size depends on the complexity of the problem and the resources available.

2. Length of each individual's encoding: The representation of the solutions in the form of chromosomes or genetic vectors requires defining the length of the coding for each individual. This length is often determined by the number of variables or characteristics to be optimized in the problem.

3. Cross probability (pc): The crossover probability pc is determined by the shape of the fitness function and is typically chosen heuristically, similar to the mutation probability pm. A higher pc value leads to more significant changes within the population. Accepted values for pc usually range between 0.5 and 0.9.

4. Mutation Probability (pm): The probability of mutation controls the frequency at which random mutations are applied to individuals in the population. A too high value of pm can result in excessive search space exploration, while a too low value can lead to premature convergence towards underoptimal solutions.

By adjusting these parameters and combining them appropriately with the core operators, genetic algorithms can be adapted to effectively solve a wide variety of optimization problems, including multi-purpose and complex problems

II.9. Conclusion

Genetic algorithms are particularly well-suited for addressing multi-objective optimization problems due to their ability to efficiently explore complex solution spaces and handle multiple conflicting objectives simultaneously. This adaptability has led to widespread adoption by researchers in various fields. Numerous genetic algorithms have been developed specifically for solving multi-objective optimization problems, incorporating diverse strategies such as encoding solutions, selection mechanisms, crossover and mutation operators, and methods for managing population diversity.

The next chapter will delve into the practical application of genetic algorithms for economic optimization, showcasing how these algorithms can be effectively utilized to optimize complex systems, such as electrical networks with the integration of photovoltaic production.

Chapter III :

Application and Results

III.1. Introduction

Renewable energy generation contributes to the In electrical systems, it is necessary to produce at all times the necessary electrical power and sufficient power to meet the demand of the load, and this demand varies considerably during the day and night, as well as the seasons and energy costs. the Production of a factory to another varies by type and efficiency. The economic and environmental study is the determination of production levels for all generators, which ensures a balance between production and consumption at the lowest cost while reducing toxic gas emissions.

III.2. Problem formulation

III.2.1 Economic function

a) Function of the cost of thermal production:

Electric energy producers experimentally determine the curves, giving the production cost of each group as a function of the power it delivers. The function associated with these curves is a polynomial of degree "n.". In practice, most often, it is presented in the form of a second-degree polynomial [15].

$$F_{th}(P_{Gi}) = a_i P_{Gi}^2 + b_i P_{Gi} + c_i \ (\$/h) \quad i = 1,2, \ldots n_g \qquad \textbf{(III - 1)}$$

$F_{th}(P_{Gi})$ is the function of the fuel cost, P_{Gi} is the power generated, ai is bi, and c_i these are the cost coefficients specific to each unit of electrical energy production and n_g the total number of generators.

b) Function of the production cost of the mini photovoltaic power plant:

The cost function of a photovoltaic mini-power plant can be represented by the following linear function:

$$(P_{pvj}) = d_j P(\$/h) \quad j = 1,2, \ldots n \qquad \text{(III - 2)}$$

(P_{pvj}) is the function of the cost of the photovoltaic mini-power plant.

P_{pv} is the power generated by the photovoltaic plant at node j.

d_j is the cost coefficient specific to the mini-photovoltaic plant, and nf is the total number of mini-photovoltaic power plants.

The cost of photovoltaic production can be obtained based on the following equations**:**

$$C_{PV} = al^p \sum(P_{pvj}) + G^E \sum(P_{pvj})$$

$$Fpvj(Ppvj) = al^p\ PPV + G^E\ PPV$$

$$a = \frac{r}{1-(1+r)^{-N}}$$

Where P_{pv} is the production of the solar energy source, a is the annualization coefficient, r is the interest rate (0.09), N is the lifespan of the investment (20 years), l^p is the investment cost per unit of installed power and G^E is the Operation and Maintenance Cost. l^p and are taken as 5000$/kW and 1.6 cents/kW, respectively for solar energy sources.[16]

$$F_{pvj}\,(P_{pvj}) = 547.7483 * P_{PV}$$

The minimization of the function of the total cost of thermal production and photovoltaic production is presented as follows:

$$\text{Min}\{F = \sum_{i=1}^{ng} F\ thi\ (\mathbf{P}Gi) + \sum_{j=1}^{nf} Fpvj(Ppvj)\}$$

Under the constraints:

$$\sum_{i=1}^{ng} \boldsymbol{PGi} + \sum_{j=1}^{nf} Ppvj - P_d - P_L = 0$$

$P_{Gi} \leq \quad \leq P_{Gi\ max}$ $\qquad i = 1, \dots, ng$ $\qquad$ (III - 3)

$0 \leq P_{pv} \leq P_{pvj\ max}$ $\qquad j = 1, \dots . nf$ $\qquad$ (III -4)

$\boldsymbol{P_d}$**:** Total active load power.

$\boldsymbol{P_L}$**:** Total active losses in the network.

P_G **:** Minimum active power of the generator.

P_G **:** Maximum active power of the generator.

III.2.2. Environmental function:

The function of gas emissions from production plants can be described as follows:

$$E_i(P_{Gi}) = \alpha_i P_{Gi}^2 + \beta_i P_{Gi} + \delta_i \text{(Ton/h)} \qquad \text{(III - 6)}$$

The environmental study consists of minimizing the function of emissions:

$$Min\ \{E = \sum_{i=1}^{ng} \boldsymbol{E_i}\,(\boldsymbol{P_{Gi}})\ \} \qquad \text{(III -7)}$$

III.3. Bi-objective and Single-objective optimization:

The economic-environmental study therefore consists of seeking the simultaneous minimization of the two functions described by the same object variables. The optimization problem represents a bi-objective or bi-criteria problem. The main difficulty of such an optimization problem is linked to the presence of conflicts between the two functions. For this, the bi-objective optimization problem can be transformed into a mono-objective optimization problem, introducing a price penalty factor Fp which represents the ratio between the maximum fuel cost and the maximum emissions of the corresponding generator . [17]

$$F_{pi} = \frac{Fth_i(P_{Gi\,max})}{E_i(P_{Gi\,max})} \quad (\$/ton) \qquad \text{(III – 8)}$$

The following steps are used to find the price penalty factor for a specific load demand.

1- Find the ratio between the maximum fuel cost and the maximum Emission

$\frac{Fth_i(P_{Gi\,max})}{E_i(P_{Gi\,max})}$ of each generator

2- Arrange the values of the price penalty factor in ascending order.

3- Add the maximum generated power of each unit (P Gimax) one by one, starting with the power of the plant with the smallest factor.

$\sum P_{Gimax} \geq P_{ch}$ we stop the calculation .

4- At this stage, F_{p} linked to the last unit in the summation process is the price penalty factor corresponding to the given charge.

The mono-objective optimization problem is presented as follows:

$$Min\ [\Psi = \sum_{i=1}^{n} thi\,(\boldsymbol{P}Gi) + \sum_{j=1}^{nf} Fpvj(Ppvj) + F_P . \sum_{i=1}^{ng} E\ (\boldsymbol{P}_{\boldsymbol{Gi}})](\$/\boldsymbol{h}) \quad \text{(III-9)}$$

Equation (III-9) can be rewritten according to the global coefficients and powers generated:

$$Min\ \{\Psi = \sum_{j=1}^{n} pvj(Ppvj) + \sum_{i=1}^{ng} A\ P_{Gi}^{2} + B_i P_{Gi} + C_i\}(\$/h)$$

With $A_i = a_i + F_p\alpha_i, B_i = b_i\beta_i$ et $C_i = c_i + F_p\delta_i$

III 4.Application

The electrical network chosen for our study is an alternating current network with 3 producer nodes [18].

The cost functions of the three generators are as follows:

F1 $(P_{Gi}) = 0.11P^2_{G1} + 5P_{G1} + 150$

F2$(P_{Gi}) = 0.085P^2_{G2} + 1.5P_{G2} + 600$

F3$(P_{Gi}) = 0.1225P^2_{G2} + 1P_{G3} + 335$

The NOx emissions equations are:

E1$(P_{Gi}) = 0P^2_{G1} - 0\ P_{G1} + 0$

E2$(P_{Gi}) = 0.00000649P^2_{G2} - 0.0005554\ P_{G2} + 0.0491$

E3$(P_{Gi}) = 0.00000338P^2_{G3} - 0.000355P_{G3} + 0.05326$

Under the constraints:

$10 \leq P_{G1} \leq 250$

$10 \leq P_{G2} \leq 300$

$10 \leq P_{G3} \leq 270$

III.4.2. optimization before the installation of photovoltaic production

The requested power is 315 MW for our study we consider the PL transmission losses negligible.

	WithoutPV
$P_{G1\ opt}$ (MW)	143.14
$P_{G2\ opt}$ (MW)	78.93
$P_{G3\ opt}$ (MW)	92.92
Production cost($/h)	5215.97
Gaz emissions (ton /h)	0.0845
Total cost ($/h)	9882.61

Table 1.III Results optimal cases without PV

Figure II.1 clearly shows the rapid convergence of the cost function towards the optimal solution.

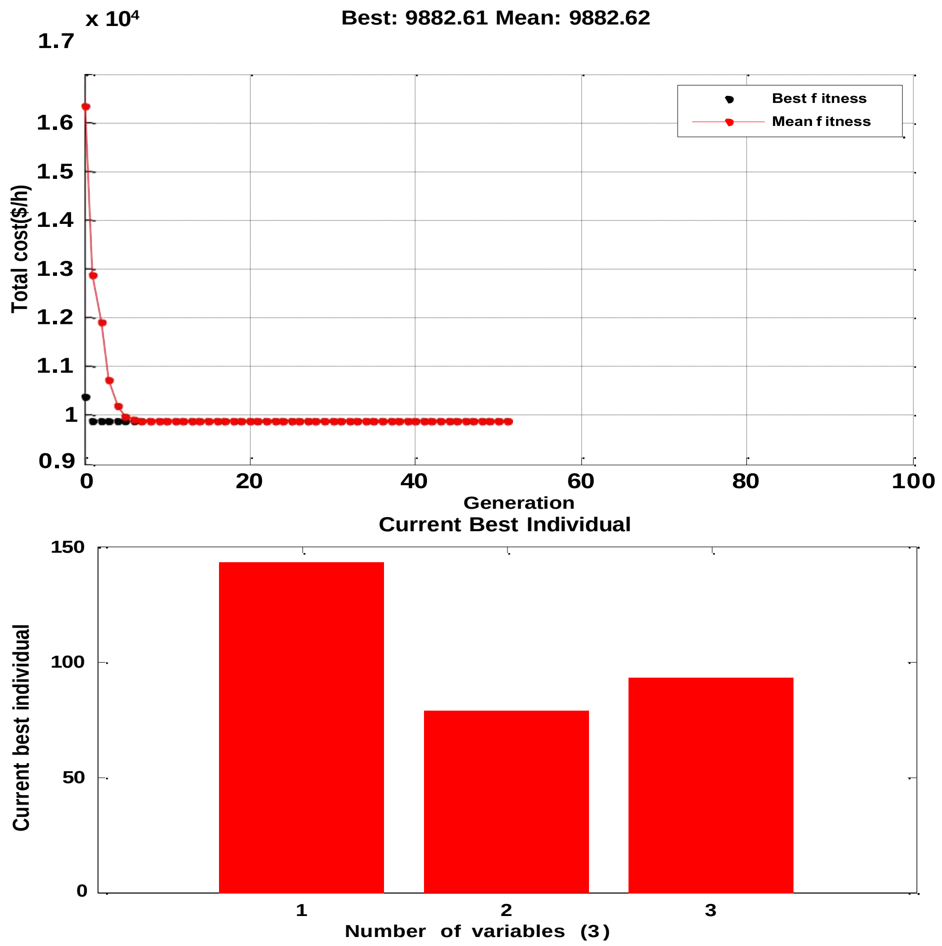


Figure III 1. Variation of total cost depending on the number of iterations (case without PV)

- The curve without PV reflects the reduction in total cost as the number of generations increases, indicating that the algorithm improves over time arriving at better and less expensive solutions. - Stability after a certain number of generations indicates reaching the saturation point or the maximum possible improvement in the constraints and available resources, that is, it shows a process of improvement across generations where the total cost decreases slightly at first and then stabilizes.

III.4.2.2. Comparison Optimal results in the presence of HAS/AG production [19]

	AG	HSA
$P_{G1\ opt}$ (MW)	143.14	143.13
$P_{G2\ opt}$ (MW)	78.93	78.95
$P_{G3\ opt}$ (MW)	92.92	92.91
Production cost($/h)	5215.97	5912.49
Gaz emissions (ton/h)	0.0845	0.08695
Total cost ($/h)	9882.61	9901.30

Table2. Comparison Optimal results in the presence of HAS/AG production

In addition to the results shown in the table, AG and HSA are similar in terms of energy production, with a difference in gaz emissions. However, AG was better in terms of production cost and total cost than HSA

III 4.3. Optimization after the installation of photovoltaic production

We resume the simulation by considering the addition of photovoltaic production in the electricity production chain. The power of the mini photovoltaic plant is equal to 110 MW.

2. The results of active powers, emissions rate and total cost are given in the table

	WithPV
$P_{G1\ opt}$ (MW)	77.35
$P_{G2\ opt}$ (MW)	60.18
$P_{G3\ opt}$ (MW)	67.46
Production cost($/h)	3135
Gaz emissions (ton /h)	0.0757
Total cost ($/h)	6722.63

Table 3.III Optimal results for the case with PV

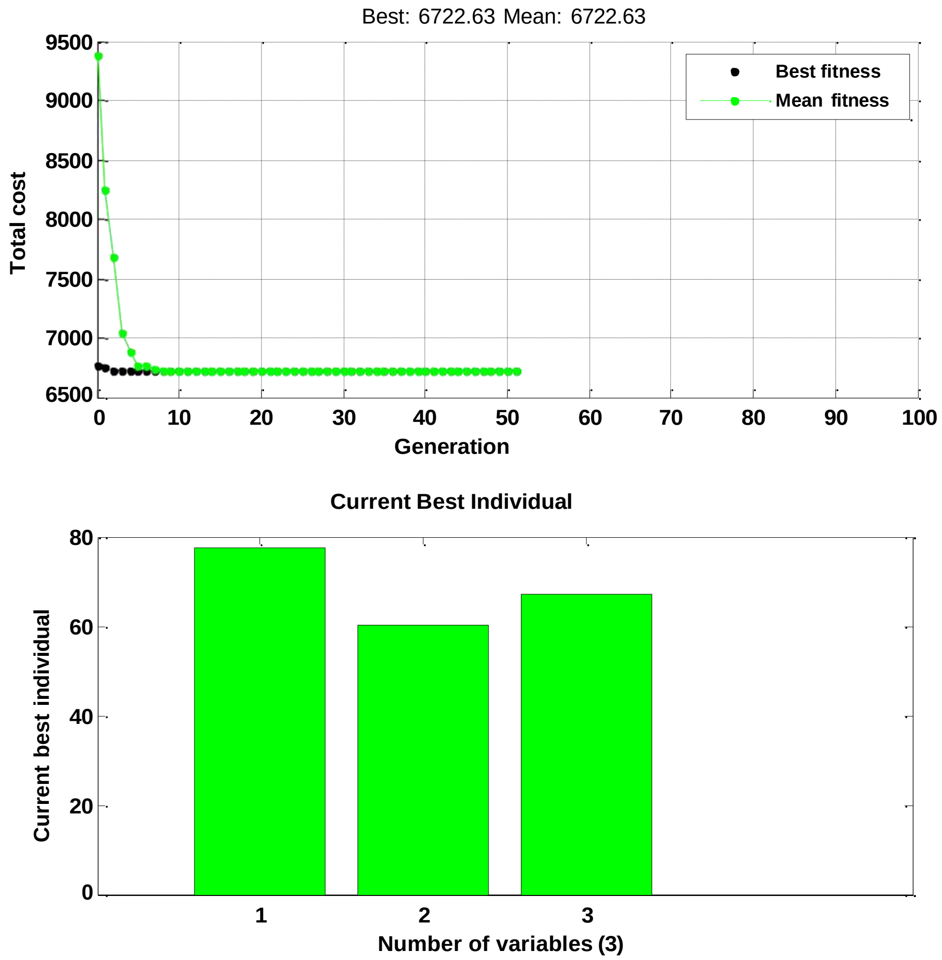


Figure III.2 presents the rapid convergence of the cost function towards the optimal solution in the case with PV.

- From the plot, we observe that the total cost drops sharply at the beginning during the first few generations (up to around 10 generations), and then it stabilizes. This indicates that the algorithm finds better solutions quickly at first, but then the improvements become smaller and less frequent. At around generation 100, the total cost stabilizes around 6722.63, suggesting that the algorithm has approached the best possible solution

- The first column represents the value of the first variable (generator) and shows it at around the level of 75.
- The second column represents the value of the second variable (generator) and shows it at around the level of 55

- The third column represents the value of the third variable (generator) and shows it at around the level of 65

- This chart gives us an idea of the current distribution of the variable values in the best current individual, reflecting the optimal composition of the individual based on the three variables.

III 4.3.2. Comparison Optimal results in the presence of HAS/AG production

	AG	HSA
$P_{G1\ opt}$ (MW)	77.35	77.52
$P_{G2\ opt}$ (MW)	60.18	60.32
$P_{G3\ opt}$ (MW)	67.46	67.14
Production cost($/h)	3135	3159.45
Gaz emissions (ton /h)	0.0757	0,07567
Total cost ($/h)	6722.63	6681.34

Table4. III Comparison Optimal results in the presence of HAS/AG production

The results after integrating PV into the electrical network showed a difference in terms of the total cost, that HSA is less than AG, and this is due to the difference in the value of the included variables (calculating transmission losses)

	Without PV	***With PV***
$P_{G1\ opt}$ (MW)	143.14	77.35
$P_{G2\ opt}$ (MW)	78.93	60.18
$P_{G3\ opt}$ (MW)	92.92	67.46
Production cost($/h)	5216.97	3135
Gazemissions(ton/h)	0.0845	0.0757
Total cost ($/h)	9882.61	6722.63

Table5.III Optimal results for two case(without PV / with PV)

III.5. Discussion

Based on the findings, it can be concluded that there is a notable disparity in the values of total cost and toxic emissions between those examined with and without photovoltaic (PV) integration:

The total cost associated with the specified load decreased from 9882.61$/h to 6722.63$/h, resulting in a reduction of 3259.95$/h, or 32.98%. Furthermore, gas emissions witnessed a decrease of 2028 KG/Day, which is equivalent to 1816,8 KG/day, or 13%.

These results underscore the significant impact of PV integration on both cost reduction and environmental sustainability, highlighting the potential benefits of incorporating renewable energy sources into energy systems.

III.6. Conclusion

The economic and environmental analysis of the integration of photovoltaic (PV) production into the electricity network using a genetic algorithm gave very satisfactory results. The comparison of the results obtained before and after the integration of PV production into the electricity network highlighted considerable savings in electrical energy production and a notable reduction in greenhouse gas emissions into the atmosphere.

General conclusion

General conclusion

This project examined the optimization of the economic and environmental dispatching of electricity networks, taking into account the integration of photovoltaic production into the electricity production chain. to begin with, a presentation of the electrical networks and the different sources of electrical energy production, whether conventional or renewable, was made. Then, an introduction to optimization techniques, particularly highlighting the method of genetic algorithms chosen for application in the optimization of economic and environmental dispatching of electrical networks, was presented. This approach aims to optimize the production cost function and the toxic gas emissions function.

The last part of the study focused on optimizing the cost function and toxic gas emissions by comparing the electricity network without photovoltaic production and with the integration of this energy source. The simulations were carried out in the Matlab environment for both scenarios. The results obtained highlighted the significant impact of the integration of photovoltaic energy into the electricity network from an economic point of view, with a notable reduction in the production costs of thermal power plants that can exceed 32.89%, as well as a significant reduction in toxic gas emissionsof up to 13%.

In conclusion, the integration of the photovoltaic sector in the production of electrical energy is a very promising initiative, in particular for producers and companies in the energy sector, because it offers economic advantages while preserving the environment. .

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