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MANAGEMENT OF ENERGY PRODUCTION

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ABSTRACT

The integration of renewable source including solar and wind power is a new challenge that can improve the profit of the electric network. Its use in the production is necessary to maintain energy efficiency. Due to the dependency of these energies on the weather condition and climate change, it seems necessary to combine the two power sources by using the strengths of a source to compensate the weakness of the other. This article aims to propose a new method for the energy production management. Moreover, we use the interpolation for the prediction of production.

Keywords: prediction, system of production, energy, interpolation, MRP method.
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1. INTRODUCTION

The production of the electrical energy in the world is increasing, and this trend increases with the industrialization and the fast growth of the population.

As shown in the graph below the statistics of global energy production:

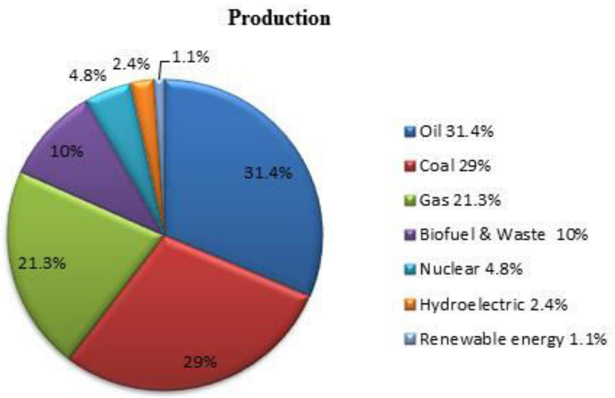

Figure-1. Global electricity production in 2013. (Source of data: Bp) [14].

According to the statistics, we notice that the world production of electricity was increased on average by 3.1 % a year between 2003 and 2013.

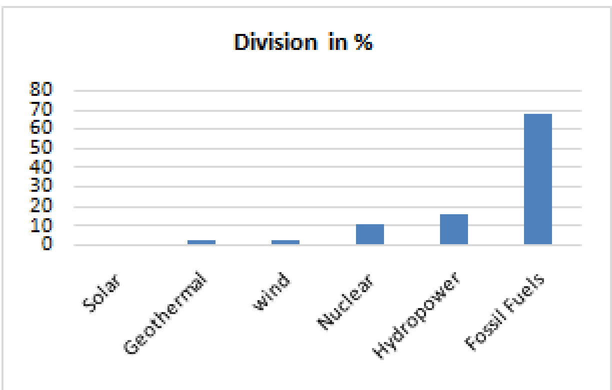

Figure-2. Distribution by source of the world production in 2013. (Source of data: Bp) [14].

Production of Electrical Energy from fossil fuels has increased more than 3.3% per year over ten years, and nuclear energy is the only technology that has cut production (- 1.1% / year). Global electricity generation from renewable energy (including large hydro dams) increased by an average of 5.3% per year. Renewable almost offset the decline of nuclear power.

Actually, most of the countries in the world lead projects and research to predict and increase the production to ensure the balance between the production and the consumption by respecting the environment
This balance is based on the integration of renewable energy like wind and solar power.

In Morocco, the population and the industrialization are growing. The development of the conventional energy resources, the exploitation of not conventional energy resources and the preservation of the power became crucial. Besides, the power consumption in Morocco increased in a fast way during the last ten years because of the combined requirements of industrialization and urbanization.

In this context, our paper has for objective: management of the power production. We took Morocco as a case study.

2. INTEREST OF THE STUDY

During the last years, most of the countries of the world have experienced a demographic and economic development, followed by a rapid increase in energy consumption, especially the electrical power. For this reason, many countries seek the balance between consumption and energy production.

The introduction of the renewable energy, allows the producer to use a reliable energy. From this perspective, our project aim is to set up a prediction system for the electric power production using for the first time the MRP II methodology.

Our paper addresses the case of Morocco, given that this country in the next ten years has to answer an increasing demand at the level of electrical energy to follow the economic evolution.

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Morocco is the only country connected to the European network, and it can become an exporting country of electric energy towards the union European instead of being an importing.

3. LITERATURE REVIEW

The research led until now, uses mathematical, statistical models for the management and the prediction of the production of the electrical energy. M. Tunç et al. studied and compared the world production of electric energy from different power sources with electricity generation in Turkey [6]. S. Jebaraja et al. presented the various types of models used in the literature such as energy planning models, model supply, and demand of energy, prediction models, renewable energy patterns, emission reduction models and optimization models [7]. C. Adjamagbo et al. suggested four mathematical models for modeling the energy demand in Togo [8]. D. Neto Studied diesel demands in Switzerland by an iterative methodology for the long term. The model based on Chebyshev polynomials in two steps for short-term dynamics [9]. P. Adom et al. have used the techniques of regression for modeling of the electricity demand in Ghana. The result showed further evidence of change in the structure of the economy of the more intensive energy sector to energy less intensive sector after the reform [10]. Chang et al. used the vector of co-integration for modeling demand for electricity [11]. B. Lennartson et al. used a predicate transition model for discrete event systems [12]. The results obtained by this model leads to a reduction of about 30% in energy consumption. H. Wang et al. have developed two models: a model for planning based on the modeling of heat and electricity. Moreover, a model to optimize the hybrid system. The results indicate that the developed model is more efficient and more flexible for hybrid systems [13].

4. METHODOLOGY

In this project, the study is presented in the Figure-3. This study collects annual data on the electricity production in Morocco.

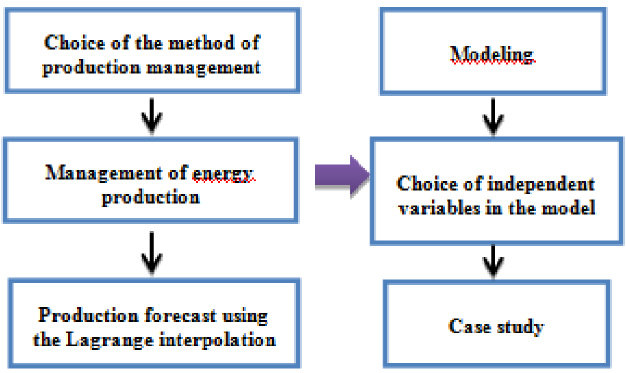

Figure-3. The stages of the study.

5. THE POWER PRODUCTION MANAGEMENT

The Energy production can be subdivided into two categories:

- The centralized production;
- The decentralized production.

Centralized production has three categories:

- Thermal power plants, fuel-based;
- Hydroelectric power plants ;
- Nuclear power plants.

The decentralized production is based on two categories:

- Wind farms;
- Solar farms.

Management and planning of energy production cannot be based on the amount of energy produced per year; this energy must be provided at the right time, leading to discern: Basic central and central tip, the ranking is based on the ease of implementation of plants. According to Figure 4 the electrical network consists of:

- **Production:** formed by means of classical and modern production that converts primary energy into electricity.
- **Transport:** it is ensured by a set of cables and lines for routing electric power to consumers of electricity.
- **Distribution:** This is an intermediary between electricity consumers who have small power.

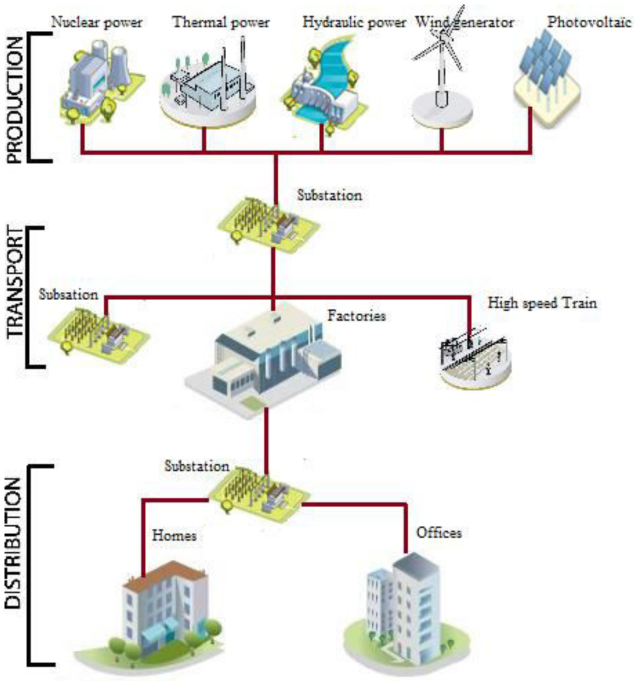

Figure-4. Description of electricity network.

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6. METHOD OF PRODUCTION MANAGEMENT

Production management methods are causing favor business logic rather than another. Among the most famous computer-aided production management tools (CAM): "manage by planning" for the method M.R.P. II, "manage just-in-time" for the Kanban method, and "manage by the means of production meant for their bottlenecks" for the method O.P.T. The production management method M.R.P (Material Requirement Planning) [1] traditionally associated with planning by the Directorate logic. The combination of different energy sources requires planning intended to describe a time scale defined by a planning horizon and an update period. A production plan answers among others the questions:

- What to produce?
- When produce?
- How much produce?

Planning aims to meet the needs of customers on time. For this reason, we choose the method M.R.P. ll shown in Figure-5. Its adaptation to the electrical network is shown in Figure-6.

The logic of management by planning appears in the method M.R.P. ll, through the chain of production plans, displaying consistent information from one level to another.

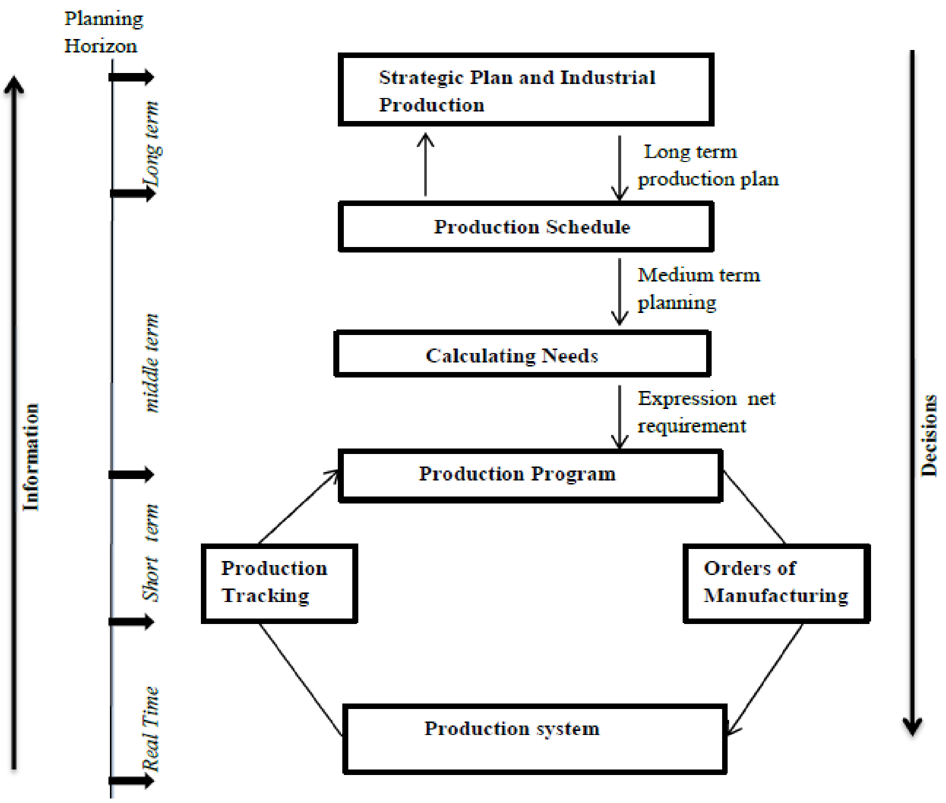

Figure-5. MRP II method [1].

The adaptation of the MRP method to electricity network is shown in Figure-6:

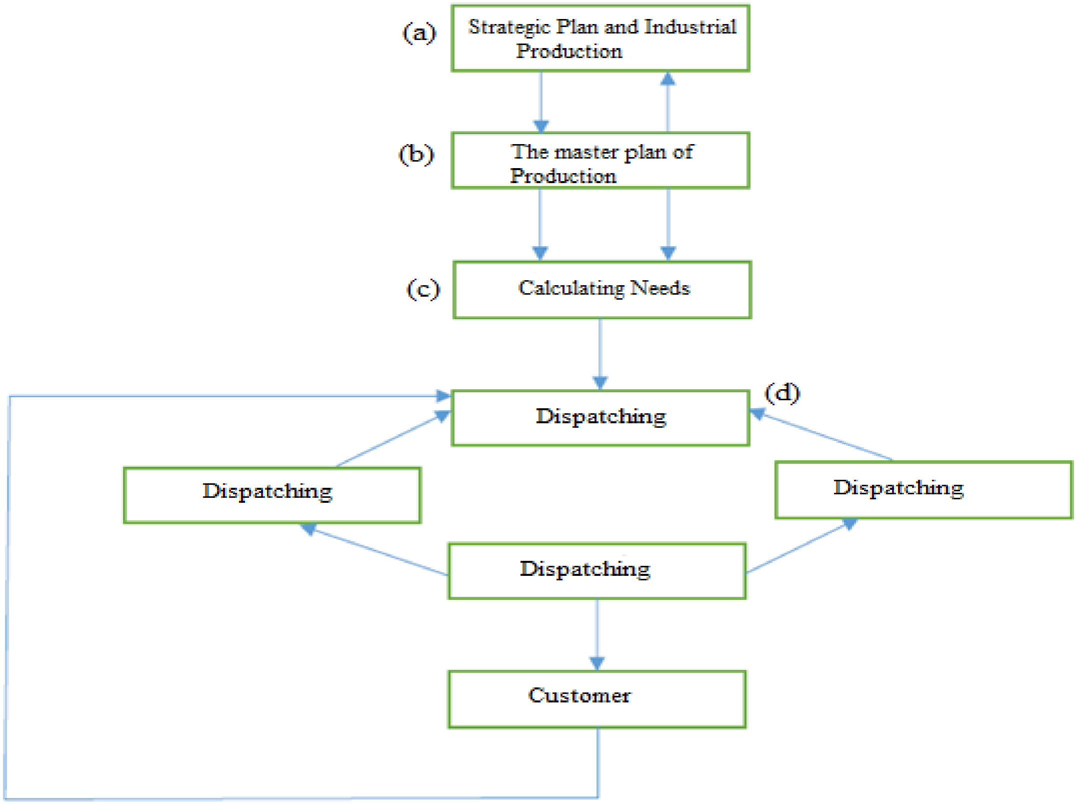

Figure-6. Adapting the MRP method to the electricity network.

7. TERMINOLOGY

a) Strategic Plan and Industrial Production

The strategic and industrial production plan means sales of known energy, based on an analysis of the history. This program brings together the capacity and technical capabilities that can cause, deducting the types of production the level of production (monthly / quarterly / annual) acceptable setting the strategic goal.

b) The master plan of Production

Through the forecast demand for energy and the production system typology (centralized or decentralized), the production Schedule interprets the objectives of these projections by leading each production plant the energy to make. The forecast variables are defined for each production system and are not related.

c) Calculating Needs

The target of this way is to determine the needs of the consumers in energies for a given period.

This requirement means the quantity of energy asked which is an economic quantity which satisfies the constraints of production cost.

d) Dispatching

The data of the calculation of needs are a set of orders of production. Every order expressed by a quantity of energy and a date. The maximal capacity of a power production plant calculates the maximal output in units of powers by units of time.

8. PLANNIFICATION

In this phase, it is a question of creating a master plan of production which establishes the daily forecasts of energy-consuming electric ones. The decisions are captured in functions of the data collected by an information system.

For the systems of power production, there are permanently several decisions to make. Furthermore, there are always risks disrupting the functioning of the systems as the climate change for the renewable energy.

9. APPLICATION

The figure below shows the six-time changes in the consumption of electricity in a day.

Figure-7. The daily consumption.

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Consumption on a day consists of 6 phases: the night dips, which corresponds to the minimum of consumption, the morning peak, the hollow of the afternoon and evening slice corresponding to the maximum use in 24 hours.

The energy consumption is not uniform during the day, every slice in linked to a quantity of energy consumed. The electricity demand varies all throughout the day and seasons.

The applying the MRP.II methodology to the electricity network:

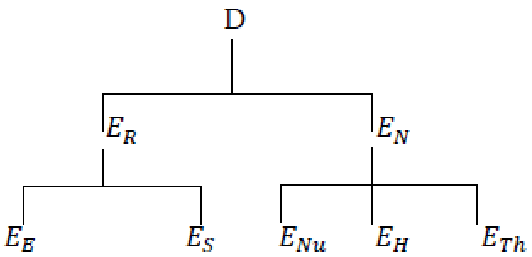

Figure-8. MRPII methodology.

The energy demand is assured by several sources of energy, in particular, the renewable energies (the wind, photovoltaic) and the normal energies (nuclear, thermal and hydraulic).

$$\sum_{K=1}^{n} \alpha_i \,.\, D = D$$

With α all slices of the day, it is the percentage of energy consumed by a slice $[x_i, x_{i+1}]$.

Table-1. Energy distribution by period.

Period	**00 :30-04 :30**	**04 :30-08 :30**	**08 :30-12 : 30**	**12 :30-16 :30**	**16 :30-20 :30**	**20 :30-00 :30**
Energy Product	E_N	E_N	E_R	E_R	E_R& E_N	E_N

This table defines the primary source of energy used in every period of the day. The transition from one energy source to another is made at the time of the need.

$$\sum_{i=1}^{n} \beta_i . E_R = E_R$$

With:

$\beta_i . E_R$: The amount of renewable energy produced in a slice.

$$\sum_{j=1}^{n} \delta_i . E_N = E_N$$

With:

$\delta_i . E_N$: The normal amount of energy produced in a slice.

In the ideal case, the productions equal the consumption. It means that in every slice we ensure the quantity of energy by using the main energy to dedicate to the slice.

According to Table.1 the formula becomes:

$$\sum_{i=1}^{3} \beta_i . E_R + \sum_{j=1}^{4} \delta_i \,.\, E_N = \sum_{K=1}^{6} \alpha_i . D_i$$

10. PREDICTION OF PRODUCTION USING LAGRANGE INTERPOLATION:

The Forecast of the levels of renewable power production in Morocco is an essential stage in the process of modelling. The objective is to lessen the power production with fossils to reduce the dependence at the level of the import of the oil and the gas. The precision of the data to forecast gives a bright prospect of the future stakes concerning the costs, the requirements and the strategies of production. The objective is to maximize the power production through the wind turbine and the solar source and to minimize the power production based on the fossil.

As mentioned, the renewable energy is represented by the wind turbine and the solar energy.

$$RE = WTE + SE$$

RE: Renewable energy
WTE: Wind Turbine energy
SE: Solar energy

$$WTE = \sum_{i=1}^{n} \sum_{j=1}^{n} \left(k_j \times x_j \times v_i\right)$$

Avec:
k_j: Transformation vector
x_j: The number of the wind turbine
v_i: The wind speed at the moment 'i'

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$$SE = \sum_{i=1}^{n}\sum_{j=1}^{n}(L_j \times I_{ij} \times D_i \times x_j)$$

Avec:
L_j: Transformation factor of the panel 'j'
I_{ij}: The average intensity at the moment 'i'
D_i: The average length at the moment 'i'
x_j: The number of solar panel

In this paper, we propose to measure the forecasting data of the energy production using the Lagrange interpolation polynomials. In fact, the interpolation is a way to represent the production history and measure the future production levels. This method is used in several fields to represent and model the data by polynomial functions [3] [4].

11. LAGRANGE INTERPOLATION POLYNOMIALS

The problem is to determinate a polynomial of degree one that passes through the distinct points $(x_0, y_0), (x_1, y_1), \dots, (x_n, y_n)$is the same as approximating a function"f". Our objective is to find a polynomial function that passes through these n+1 points, called (an interpolating polynomial).

The general formula for the Lagrange interpolating polynomial is:

$$\boldsymbol{P(x) = \sum_{i=0}^{n} l_i(x).y_i = \sum_{i=0}^{n} l_i(x).f(x_i)} (1)$$

We use Lagrange basis polynomials: (2)

$$l_i(x) = \prod_{\substack{m=0\\m\neq i}}^{n} \frac{x - x_m}{x_i - x_m} = \frac{x - x_0}{x_i - x_0} \times \dots \times \frac{x - x_{i-1}}{x_i - x_{i-1}} \times \frac{x - x_{i+1}}{x_i - x_{i+1}} \times \dots \times \frac{x - x_n}{x_i - x_n}$$

The objective of the approximation is to define a curve which best approaches a data set (each defined by a pair) (X, Y) in order to determine the future data.

The choice of Lagrange interpolation is based on the nature of data and the production history. Lagrange polynomials are unique and give us the best approach to the set of point f(x) = y regarding their nature [5]. Although this method has some restrictions; the interpolation technique cannot be used to determine long term forecasting data because the polynomial functions has a parabolic limit. This characteristic reduces the study to a limited forecasting time.

A comparison with other digital methods such as Cubic Spleen is in progress, to value the impact of the approximation of the consumption on the model.

12. THE FORECASTING METHODOLOGY MODELING

The study concerns the modeling of the renewable energy in Morocco. The objective is to define the forecasting production data in order to measure and balance the production and demands while minimizing the costs.

Let's considers the following initial data:
I: the set of the previous production years,
$\mathrm{card}(I) = n, i \in [\![1.n]\!]$

$$RE(i) = WTE(i) + SE(i)$$

The renewable energy related to the production year number "i".

So the interpolated polynomial function related to the production history is:

$$P(x) = \sum_{i=1}^{n} l_i(x) \times RE(i)$$

However, to determinate the forecast production value, we should measure the value of the polynomial function:$P(x+1)$.

As mentioned above, this method gives a good interpolation measurement but it is restricted to a limited number of forecasting data. To enhance this result, we can for future research include and consider the exponential refinement or the trend and seasonality techniques to effectively represent the production seasonal change due to the climate change.

13. CASE STUDY

Our study based in Morocco, who knew an evolution of the energetics. The used data are annual and submit the request for energy and the electricity production.

The economic and demographic development in Morocco encouraged the country to look at another source of energy to supply the internal needs and to minimize the energy dependence while respecting the environment.

The strategic location and the climate urge the country to use the solar energy and the wind as a renewable energy to answer these needs.

Figures below show the evolution of the demand for energy during 17 years and the power production by the wind power during the last five years.

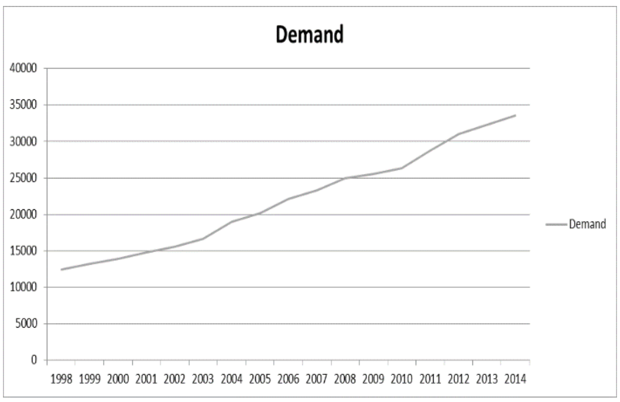

Figure-9. Evolution of the demand of energy (1998 to 2014).

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The Figure-4 shows that in the last five years the demand increases in a fast way thanks to new industrial parks.

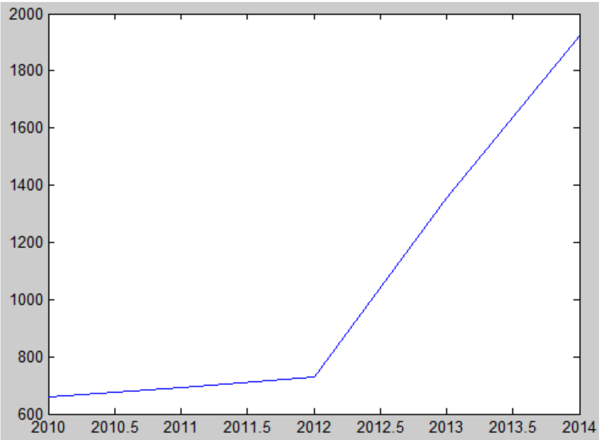

Figure-10. Development of energy production by the wind.

In 2012, the production of the wind energy was quickly increased thanks to the construction of a new wind farm. Morocco has a considerable potential for the generation of the solar energy. As regards the solar energy Morocco has not yet begun to produce some energy. The results obtained by the used precise method are shorter and have significant implications for the structural analysis

- For year 2015, we received 2, 457.906 GWh;
- For year 2016, we obtained 2, 845.155 GWh.

The Forecast of the power production is difficult because it is affected by the economic and demographic development.

Consequently, the development of a predictive model is crucial. Moreover, the proposed model is able to predict with more precision and reliability.

14. CONCLUSIONS

The proposed method of production management facilitates the change of role from a source to another one in the chain of the electrical energy to control, supervise and oversee in real time the value which can be reached thanks to the use of the systems which manage the electrical energy

The future evaluations of the power production are also necessary to limit the climate change. The models of forecasting can show if the amount of the energy production can be affected by the climate change or not.

To improve this result, we can, as future research, use the refinement exponential or the techniques of trend and the seasonality to represent the seasonal changes of production efficiently due to the climate change.

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NOMENCLATURE:

D : Demand $\mathbf{E_S}$: Solar Energy
$\mathbf{E_R}$: Renewable Energy$\mathbf{E_{Th}}$: Thermal energy
$\mathbf{E_N}$: Normal energy $\mathbf{E_H}$: Water power
$\mathbf{E_E}$: Wind power$\mathbf{E_{Nu}}$: Nuclear Energy