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One day ahead prediction of PV power production: case study of Oued-Elkebrit's station (Algeria)

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***Abstract*— The research work presented hereafter is based on real recorded database of a PV plant in production and in connection with a classical electrical grid. Datasets were processed through two types of techniques. The first one, a classical type, is based on a predictive predefined model, however, the second one is an artificial intelligent method based on neural networks. Based on the carried out experiences, we proposed a new strategy to implement the proposed techniques. The results obtained through the two methods were compared which demonstrate the superiority of the AI method in terms of precision, generalization and robustness. Obtained results for each method were recorded, analyzed and compared.**

Keywords—Renewable energy, Forecasting, PV plant, Power production, Neural network

I. INTRODUCTION

The energy on its different forms represents a vital constituent of the human life. In the course of its historical evolution, humanity has increasingly needed to consume more energy in more and more forms. The last two centuries have seen an exponential increase in the amount of energy consumed. Industrial development, consumption development, new technologies, etc. have boosted this trend to consume more and in different forms. However, the last two decades have seen an awareness of the dangers facing humanity as by continuing in this destructive policy of energy and environmental resources of the planet. All over the world, we are beginning to see the effects of this policy from the climate point of view and we began to see the limits of potential and natural resources. A new trend emerged among researchers from around the world; it consists of looking for other forms of renewable energies, sustainable and friendly to the environment. After two decades, we begin to perceive a growing hope in some of the resulting new trends and technologies of producing energy from natural renewable resources especially the sun the wind and the biomass [1]. Moreover, some of these technologies as the photovoltaic and the wind have passed the experimental stage towards the practical production stage [2], [3], [4]. Global word-wide production of these two types of new resources began to take place as possible replacement solutions especially in rural and poor areas [5].

However, such new technologies still encounter many challenges that have to be overcome. These challenges are of different types beginning by economical ones, technical ones and even social challenges [6]. Technical problems received particular interests by researchers since improvements in such profile permit improvements for all encountered problems and facilitate insertion of such technologies in the industries and even in the day-life of the society.

Among renewable energy solutions, photovoltaic systems became one of the most successful and promising technologies of the new trends. PV electricity production benefits from the large deployment of the principal resource, namely the sun and its relative availability in almost regions of the world. PV systems have been set up to function as completely independent systems and thus provide electricity to individual communities [7] or as systems integrated into conventional power grids [8]. Each one of these configurations rises its own problems and challenges. However, a well known challenge that is common for each of them is the problem of intermittence. Indeed, it's a real and practical problem that is related to the nature of the resource (the sun) and its interaction with some other geometric (day vs night) and climatic (clouds, temperature, wind speed, humidity and pressure) characteristics of our planet [9] [10]. This major problem was largely studied by researchers and two principal strategies were proposed to limit its effects on the designed PV production plants. The first strategy is based on the development of storage components and structures for the produced electrical energy and the second one is based on the prediction of the PV plant's electrical production. Our proposed research work presented hereafter will deal with the intermittence problem according to the second strategy by studying and comparing two techniques applied to a real database recorded on a real PV plan already in production and in connection with a classical electrical grid.

In the following of this research paper we will firstly give an overview of the principal methods and techniques used as forecasting solution to the intermittence problem on the PV plants then we will introduce, in section 3, the two methods that

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will be investigated according to the PV plant's database. In section 4, we will give a detailed statistical analysis of the datasets of the working database. Section 5 will contain the obtained results and their discussions. We will finally give the conclusions and the perspectives in section 6.

II. FORECASTING TECHNIQUES AND METHODS OVERVIEW

Due to the fact that the solar radiation represents an enormous amount of free, economic, largely deployed, simply accessible and friendly environment mine of energy, it received a special attention by researchers, economists and even politicians around the world. This attention participates in its fast development and deployment which permits a real growth in worldwide PV production. Indeed, according to the IEA (International Energy Agency) in an interval of ten years, the world produced electricity by PV plants passed from the reduced number of 11.9 TWh in 2008 to the phenomenal amount of 570 TWh in 2018. The SDS (Sustainable Development Scenario) forecasts an annually 16% growth of electricity PV production which will led it to about 3300 TWh by 2030.

However, production development depends essentially on technical improvements of the principal related parameters and the capacity of realized researches to overcome the principal encountered challenges. As one of the inevitable and unavoidable problem in PV electricity production, the intermittence phenomenon of the solar radiation received a particular attention by community of the researchers of the domain. As mentioned in the introduction of this paper, two solutions were adopted to deal this problem. The first one is the development of storage means and the second one is the prediction or as commonly called forecasting strategy.

Forecasting techniques and methods can be classified according to three criterions. The first one is the temporal extent of the prediction process. According to this criterion, forecasting can be performed in short-term covering the period from one second to 24 hours ahead [13], [14], [15], medium-term from 24 hours and up to one month [16], [17] and long-term forecasting for periods up one or more years [18], [19]. According to the second criterion which is parameters used as inputs of the prediction system, forecasting techniques can be classified in two principal classes; techniques based on climatic parameters [20] [21] [22] and those based satellite images and weather forecasting techniques [23] [24]. The last criterion which was considered for this type of classification is the processing technique. Here also, two principal classed could be considered; techniques based on classical processing methods such as ARMA, ARIMA and ARX [25][26] and those based on the so called intelligent processing methods like ANN, fuzzy, bee colony, Genetic algorithms etc [27][28][29].

However, this classification still partially incomplete since combined techniques are also used in many research papers. Combinations are intra-criterion and inter-criterion.

III. GLOBAL STATISTICS ON DATASETS OF THE DATABASE

The database contains measures of the global power produced by the PV plant and the five related climatic parameters, namely the solar radiation, the temperature, the humidity, the atmospheric pressure and the wind speed.

Here after we expose some of the basic statistics of the recorded database.

- Figure 1 shows that the monthly average of the total irradiation in 2017 varies from 183.08 W / m² during the month of January to 528.88 W / m² during the month of July, and from 219.99 W / m² during the month of January to 525.64 W / m² during the month of July for the year 2018. The annual average of the global radiation during 2017 is 359.23W/m² and 356.82W/m² for 2018.

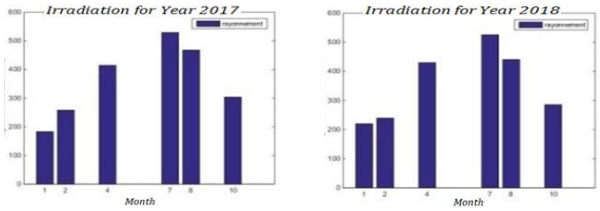

Figure 1 Monthly irradiation average of the PV plant during 2017 and 2018

- The maximum value of the monthly average temperatures appears in July (31.85°C) for 2017 and also in the same month July (33.14°C) for 2018, while the minimum value is recorded in January (7.16°C) for 2017 and in February (9.22°C) for 2018. The average annual temperature during 2017 is 20.06°C and for 2018 19.73°C. (Figure 2).

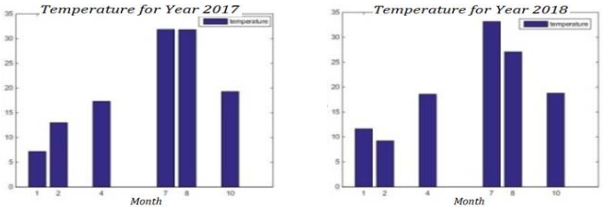

Figure 2 Monthly temperature average of the PV plant during 2017 and 2018

- The lowest monthly average of the relative humidity (during the summer) exceeds 28% for 2017 and 26% for 2018 (Figure 3), while the highest monthly average (during the Winter) is 55% for 2017 and 58% for 2018. Annual average during 2017 is 42.92%, and 47.30% in 2018.

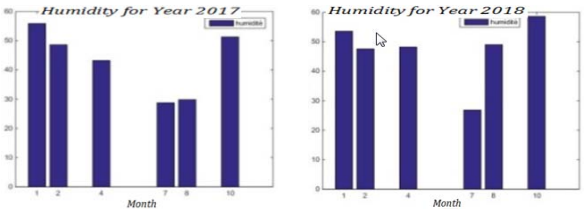

Figure 3 Monthly humidity average of the PV plant during 2017 and 2018

- The maximum value of the monthly wind speed averages appears in January (4.97 m/s) for 2017 and in February (4.72 m/s) for 2018, while the minimum value was recorded in October (2.99 m/s) for 2017 and in August (3.09 m/s) for 2018. The annual average wind speed in 2017 is 3.77 m/s and 4.01 m / s in 2018.