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Load Forecasting Based PV Power in Oued Nechou

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***Abstract*— Load forecast based photovoltaic power is important for sizing system, optimal operation of power system, and it is important task in renewable energy planning and operating. The aim of this paper is to forecast laod and PV power in Oued Nechou (Ghardaia, Algeria) based irradiance parameters, the capacity of PV plant is 1.1 MW, connected to micro grid for satisfy the electricity demand, the PV forecasting models based on historical loads and irradiance, in summer 2014 and in winter 2015, by using neural networks (NN). The results are discussed showing that forecasting error depend on irradiance, loads, and model choice. The forecast error may be improved by the other models and optimization techniques that train the neural network.**

***Keywords*—Load Forecasting, PV Power, Micro grid, missing power, Neural Networks**

I. INTRODUCTION

Recent studies of renewable energies represent as the most desired sources and modern where solar energy is one of the major and most dominant in our country namely photovoltaic solar panels that receive extended interest on their use, where multiple projects have been bet by the Ministry of Algerian energy source that used this prediction and to have 30% of national production is from renewable sources ensure the horizon of 2030. Different source types are interested in this program are: solar thermal, solar photovoltaic, wind, geothermal and biomass. Solar photovoltaic will benefit from a share of about 1168 MW the horizon of 2020[1].

The forecasts are key to the reliable and cost effective large scale integration of photovoltaic (PV) systems into electricity grids. In addition, prediction of PV electrical is also required for the planning and resizing of large scale PV plants, balancing control, electrical system stabilization, green electrical transactions, electrical interruption warnings in autonomous electrical systems and so on [2][3].

The forecasting methods are experience forecast, such as electricity elasticity coefficient, integrated electrical consumption, output and growth rate of consumption, extrapolation forecast and district load density index method. Such methods need to the value, yield and growth rate, and other data [4].

The statistical analysis methods used in the electrical forecasting are regression analysis and time series, such as linear regression model, multiple linear regressions model, nonlinear regression analysis, autoregressive (AR) model, moving average (MA) models, autoregressive moving average (ARMA) model and nonstationary time-series. The statistical analysis methods need some relationship of values and the changes among identify consumption, load, time, total output value of industry in electricity gross domestic product, and then use mathematical models to forecast. The entire process is projected to ongoing mathematical model calibration and adjustment process, which will be taken longer time to complete [5][6].

The intelligent methods based electrical forecasting are expert system, grey generation, fuzzy logic, artificial neural networks, which used in the economic environment changes, and other random factors interfere with the electrical system under load accurately forecast, which widely used to analyze numerous uncertainties and the electrical load forecast correlation. But how accurate will describe the criteria adopted for the artificial uncertainties are relatively difficult. This paper provides a neural network models based on the temperature and irradiance data [7][8].

Our contribution is to establish an accurate forecast of laod and PV power in Oued Nechou (Ghardaia, Algeria), based irradiance parameter by develop a forecasting model which will be able to consistently forecast the energy generated by photovoltaic modules using explanatory variables available at most weather stations. Solar energy Forecasts contribute to a better integration of photovoltaics into the existing power plant. So this study capable to enable future photovoltaic projects in Ghardaia city to be deployed at a much faster rate and at lower costs.

II. MATERIALS AND METHOD

The PV plant is located in Ghardaia based on the type of polycrystalline panels, inclined at 32 ° with a total capacity of 1.1 MW (Figure 1).

Fig. 1 1.1MW PV plant in Oued nechou (Ghardaia)

The equivalent schematic network (PV micro grid) is presented in Figure 2.

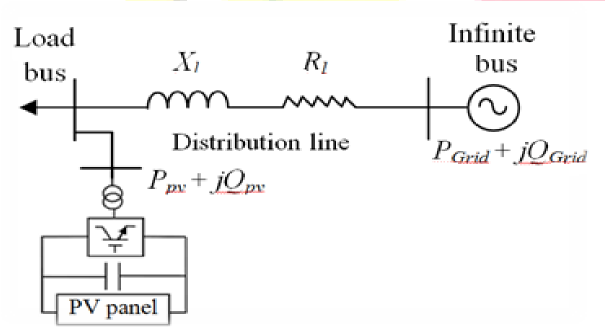

Fig. 2 Micro grid of Oued nechou (Ghardaia)

The estimation of the real value of photovoltaics (PV) power aid the dispatching center to forecast the total power production. It should be have at any moment the balance between power supply and load demand which is given by the following formula:

Load= Classical plants power + PV Power + losses

$$L = P_c + (P_{PV} + \Delta P_{PV}) + P_L \qquad (1)$$

L : Load

P_c : Classical plants power

P_{PV} : PV power

ΔP_{PV} : PV power variation

P_L : Losses power

PV power variation requires monitoring by an expert system to ensure better management of our electricity grid. The broad penetration of intermittent sources can cause significant impact on the power system operation, for example the coordination of voltage adjustment which related to injections of active and reactive power of different existing sources on the network, so the forecasting objective is to minimize the gap between production/consumption and optimize the production plants.

The mathematical model of an artificial neuron (Figure 3) consists essentially of an integrator that performs a weighted sum of its inputs. The result n of this sum is then transformed by a transfer function f which produces the output of a neuron. The R input neurons correspond to the vector P = [p1, p2,…, pR]T, whereas W = [w11, w12,…, w1R]T represents the vector of the weights of the neuron. The output n of the integrator is given by the following equation:

$$n = \sum_{j=1}^{R} w_{ij} p_j - b \qquad (2)$$

To verify the performance of the forecasting model, we can calculate the mean absolute error:

$$MAE = \frac{1}{n} \sum_{i=t}^{n} \left| P_t - \hat{P} \right| \qquad (3)$$

P_t : Desired Power

$\hat{P}_t$: Forecast Power

n: Number of samples

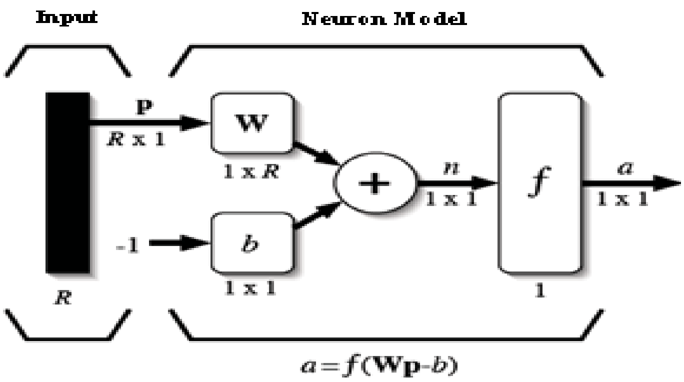

Fig. 3 Model of an artificial neuron

The load forecasting model depend on historical load data as folow :

$$\hat{L} = f(L) \qquad (4)$$

$\hat{L}$: Forecast load

L : Actual load

The PV forecast model depend on irradiance parameter in winter season and in summer :

$$\hat{P}_{pv} = f(I) \qquad (5)$$

$\hat{P}_{pv}$: Forecast power PV

I : Irradiance

The winter irradiation period is from 9h00 until 18h00, the maximum radiation value is 951 W/m2 at 13h00 (figure 4).

The irradiance in summer begins from 8h00 until 20h00; the range of irradiance is 12 hours. The cloud makes the minimum irradiance of 33 W/m^2 at 14h00 (figure 5).

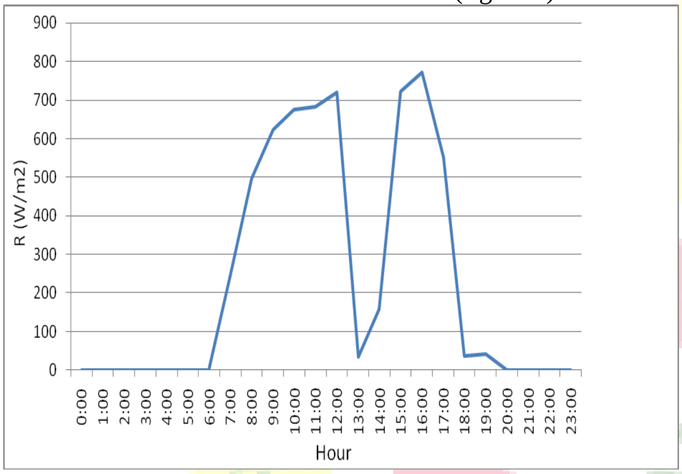

Fig. 4 Irradiance 15/07/2014

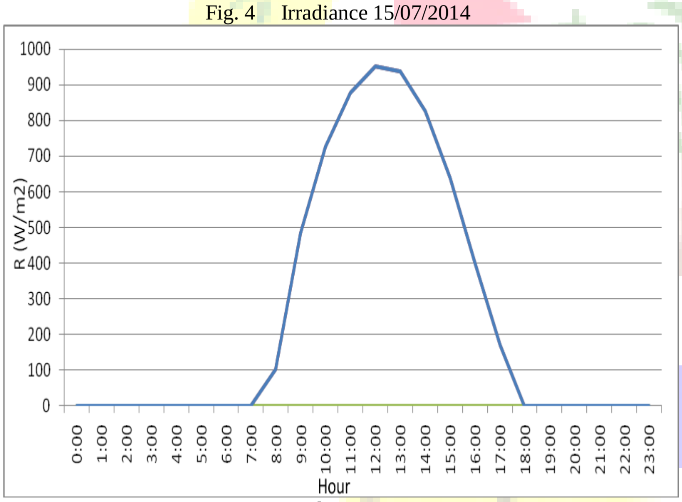

Fig. 5 Irradiance 13/01/2015

III. Simulations

To validate the forecasting models, in terms of the mean absolute error, we must test its in differents seasons (summer, and winter), to predict the PV power and load in one day ahead.

The relationship between the PV power and radiation is proportional, so as soon as the irradiance increases, the PV production increases and vice versa. The average error of PV power forecast is 45 KW in summer (Table 1). The forecast is accurate except in peak hours and in hollow ones (Figure 6).

The load forecast pace is almost superimposed on the current load profile (Figure 7); the average forecast error is 21.8 KW in summer (Table 1).

The missing power in summer varies between 54.3 KW and 1458.1 KW (Table 1); the PV production is low in the extremities of the day, either at sunrise or at sun layer (Figure 8).

TABLE I
PV POWER AND LOAD FORECAST IN SUMMER

Hour	**PV Forecast (kW)**	**Load Forecast (kW)**	**power missing (kW)**
8	76,3	1197,2	1120,9
9	529,0	1024,4	495,4
10	680,5	814,7	134,2
11	750,1	814,7	64,6
12	754,3	822,2	68,0
13	765,0	819,3	54,3
14	45,8	814,7	768,9
15	61,5	872,4	810,9
16	765,3	1197,2	432,0
17	764,6	1197,2	432,6
18	600,3	1408,5	808,2
19	46,2	1504,3	1458,1
20	46,7	1504,3	1457,6
MAE (kW)	45,0	21,8	

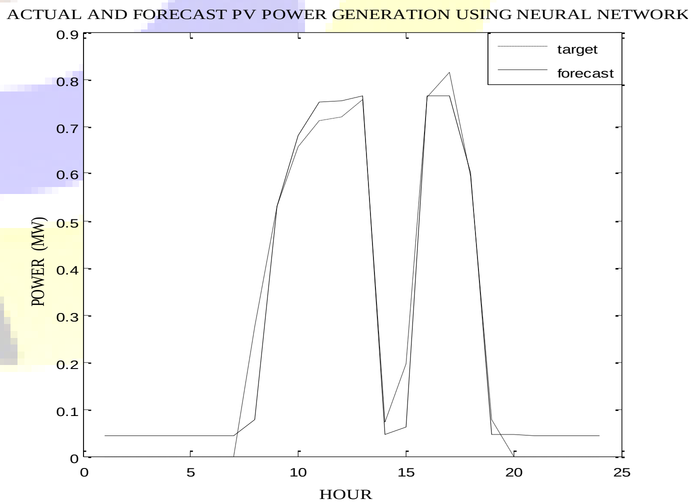

Fig. 6 PV power forecasting in summer

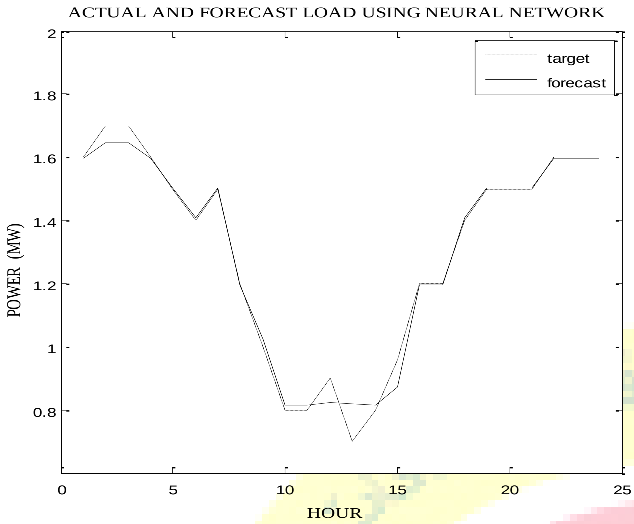

Fig. 7 Load forecasting in summer

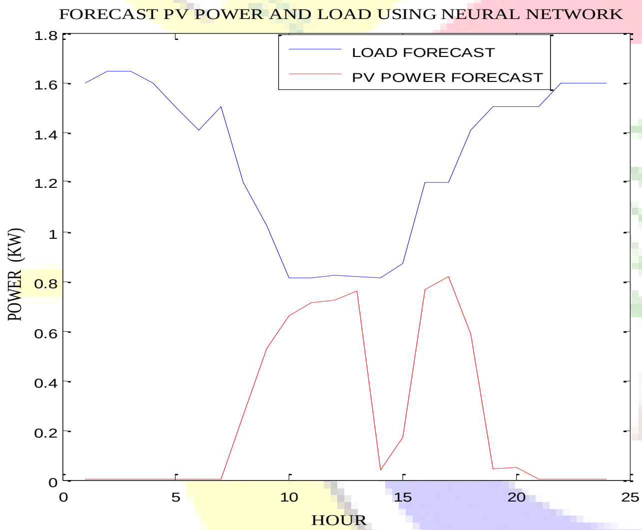

Fig. 8 Power and load forecast in summer

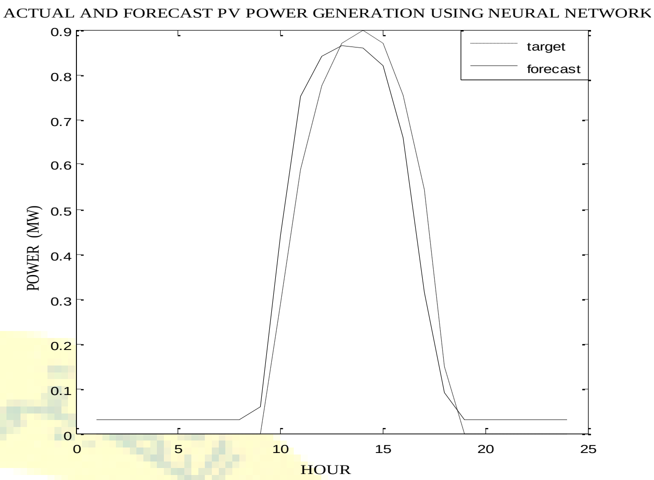

Fig. 9 PV power forecasting in winter

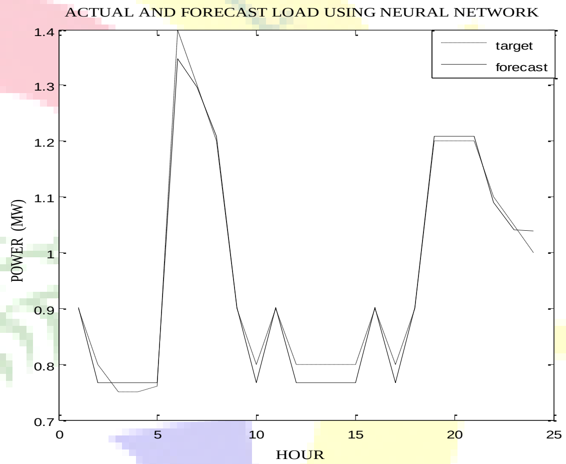

Fig. 10 Load forecasting in winter

In winter, the PV production increases gradually up to 900 KW at 14h00 (figure 9), the average error of PV power forecast is 56.02 KW (Table 2).

The peak load is 1,400 KW in morning at 6h00, and the afternoon is 1,200 KW at 19h00 (Figure 10), the average error of load forecast is 17.7 KW in winter (Table 2).

The missing power at 12h00 until 15h00 is negative (Table 2), it means that the PV production is more than electrical consumption (figure 11), in this case the PV plant is sufficient for the load in Oued nechou (Ghardaia).

TABLE III
PV POWER AND LOAD FORECAST IN WINTER

Hour	PV Forecast (kW)	Load Forecast (kW)	power missing (kW)
9	59,0	901,2	842,2
10	441,6	766,8	325,2
11	752,0	901,2	149,1
12	840,8	766,8	-74,0
13	863,5	766,8	-96,7
14	860,3	766,8	-93,4
15	818,7	766,8	-51,9
16	660,3	901,2	240,8
17	314,5	766,8	452,3
18	90,8	901,2	810,4
MAE kW)	56,02	17,7	

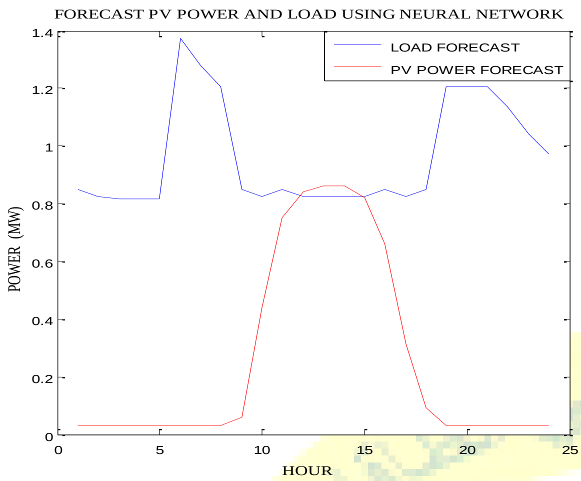

Fig. 11 Power and load forecast in winter

IV. Conclusions

Photovoltaic electrical forecasting is important to the operation of electrical system to make decisions by the dispatching center that cares to ensure electrical network security management while having a reliable and cost effective production system that meets specific environmental constraints.

The work initiated in this paper aimed to achieve a program that can predict the electrical generated by a PV plant to one day ahead in Oued Nechou (Ghardaia, Algeria), and analyze the relationship between meteorological factors and the electrical supplied by applying the neural network technique. The neural networks does not require a mathematical model, but is based on artificial intelligence.

Power consumption in summer is longer than that in winter due to use of air conditioning, which is why the load forecast error is big in the summer season. PV production linked directly with the irradiance factor, the irradiation time in summer is 12 hours, but the PV plant is not able to satisfy the electricity demand. Irradiation in winter is low, but it meets the load from 12h00 until 15h00. The forecast error of PV power depends on irradiation, but it may be improved by the other models and optimization techniques that train the neural network.

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