J. Electrical Systems 21-01 (2025): 179-186

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Artificial Neural Network for Hybrid System Management of PV for Stand-Alone Applications

Journal of Electrical Systems

Abstract: - Considered as the solar energy as a new and clean energy, has attracted much attention. But it remains problematic System management and energy storage are the biggest drawback.so This paper presents a novel intelligent energy management system, this management system depends on external data such as temperature and time, and uses an artificial neural network algorithm. For storage we suggested system consisted of fuel cell and battery, to avoid battery disadvantage and extend its lifetime, due to the high hydrogen efficiency. This study presents a noteworthy investigation into the residential application of a photovoltaic, battery, and fuel cell hybrid energy system. The focus on the distribution and storage of electrical energy for stand-alone applications highlights the potential of such systems in promoting energy independence and sustainability.

Keywords: Management system, ANN, Photovoltaics, fuel cell, hydrogen, battery.

I. INTRODUCTION

Solar energy, is technology Discover to dates back a long time and has recently returned to the forefront. Has evolved significantly over the millennia. Initially harnessing the sun's heat for basic applications, today's advancements, particularly in photovoltaic (PV) systems, underscore its vital role in renewable energy. The remarkable installation of approximately 136.5 GW of PV capacity by the end of 2015, as reported by the International Energy Agency, highlights its increasing importance in sustainable energy generation. This underscores the potential and necessity of further innovation in solar energy technologies. (IEA) [1].

Photovoltaic cells (PVCs) is an electronic device It works to produce Electricity from solar energy, which comes in the form of radiation. Through the photovoltaic effect [2]. Today, photovoltaic systems are It has great capacity. Of transforming small amount of solar energy falling on one square meter into a sufficient quantity of electricity. It can power Many Essential appliances for daily life at home. This means, he sun-facing roof space of home enough to produce the electrical energy needed to operate the house about 8500-kilowatthours of electricity annual. It is the same electricity consumption rate for a family home [3].

Standalone system is used in isolated and rural, as it addresses the energy needs of communities lacking Power plants, and access to conventional infrastructure, or in residential areas where there is fluctuation in the distribution of electricity. The systems are connected to a reservoir of energy such as battery and fuel cell. Innovation is back the fuel cells to about 165 years. By knowing that the electrolysis process is a reversible process, these systems electrochemically oxidize a fuel source to produce electricity [4]. A fuel cell consists generally of the electrodes and an electrolyte separates them. There are many types of fuel cells, which vary in according to type of electrolyte. Which may consist of hydrogen or a simple hydrocarbon. Electrolysis systems have a number of advantages,

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among which such as ecological cleanliness, high electrical efficiency considerably small mass–volume characteristics, a wide range of sizes and power costs [5], [6].

II. METHODS

A. Artificial neural network (ANN)

Artificial neural network (ANN) widely used in renewable energy research over the last period. Indeed, it has many advantages, the most important of which are their self-learning capabilities and their potential to generate outputs beyond the initial inputs. This innovative computational model, reflecting the intricacies of human neural architecture, underscores the significance of interconnected nodes in processing information. Such advancements in ANN technology hold great promise for various applications across multiple fields. Comprising interconnected nodes or "neurons," ANNs process information through layers, enabling them to recognize patterns and make decisions based on input data [7].

The multilayer perceptron (MLP) is a foundational architecture in neural networks, characterized by its structured layers—input, hidden, and output, or more layers. It effectively utilizes weighted sums and transfer functions to facilitate complex data processing and decision-making, thereby show casing the power of learning techniques. ANN Represent a black box, with relationship between input data and output parameters non-linear, as shown in Figure 1, was used for the predictions. Fig 1 shows an MLP array with five input variables (solar radiation, time, day, season and charge), a hidden layer with arbitrary neurons and four output parameters to select the power source supplying the charge.

Fig 1 illustrates the general structure of an Artificial Neural Network (ANN) model used for estimating building energy use. In this structure, there are typically three layers:

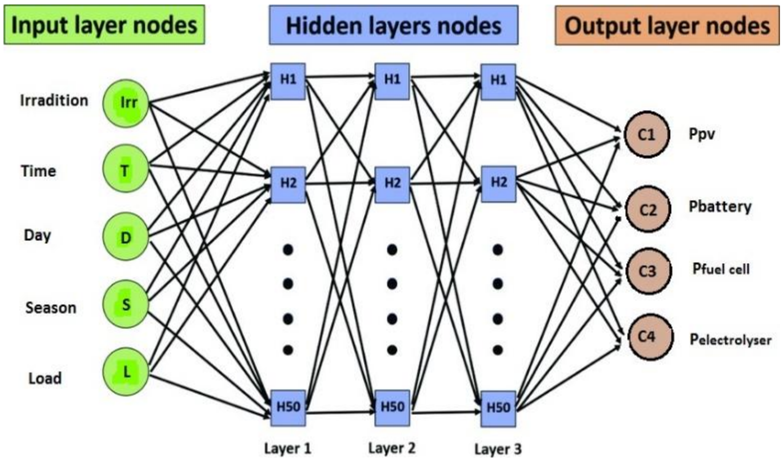

Figure 1. ANN Management

Input Layer: This layer accepts various environmental variables that serve as input to the model.

Hidden Layers: These layers process the input signals and convert them to outputs through a series of interconnected neurons. The hidden layers perform the necessary computations to extract features and patterns from the input data.

Output Layer: This layer presents the final response, reflecting how the input layer interacts with the hidden layers.

The three most commonly used types of ANN models are: Feed Forward Networks: These networks have connections that move in one direction—from input to output—without any loops. Competitive Networks: In these networks, neurons compete to respond to the input, with only one or a few neurons being activated at any given time. Recurrent Associative Memory Networks: These networks have connections that allow feedback loops, enabling them to maintain memory of previous inputs. Each of these network types employs different learning rules to adjust the weights and biases during training, ultimately influencing how they model and predict building energy use [8].

The ANN is used to identify missing sensor data from the power system. The neural network consists of two stages, namely the training and testing stage. In the training phase, the neural network is formed using a training data set generated in the first stage, and in the test phase, if the number of sensor data is to be given as input, Missing sensor data is classified to restore their missing data which is obtained as output.[9].

The input-output formulation of neurons in the hidden layer is determined by applying a non-linear transfer function to the weighted sum of the inputs plus a bias term. For a given neuron, this can be mathematically expressed (1).

$$f(Y_{net}) = f(\sum_{l=1}^{N} \omega_{l,i} X_{i,j} + \alpha l) \qquad (1)$$

f is the nonlinear activation function (is 'tansig' function) as (2) is defined:

$$y_j = \frac{2}{(1+e^{(-2x_j)})} - 1 \qquad (2)$$

the following terms be defined as:

$X_{i,j}$: The input vector;

Y_{net}: the output of the network;

a_l: the bias values of nodes;

$w_{i,j}$: the connection weights from the input node to hidden nodes;

N : equal to the number of input parameters.

B. Proposed approach

We propose the development of intelligent energy management using artificial neural network (ANN) technology for an alternative power plant composed of three types of photovoltaic, fuel cell and battery power sources as the last backup. The three energy sources are integrated in order to increase the reliability of the system in terms of compliance with the electrical energy demand in all cases. Figure 1 shows the proposed system model.

In this work, artificial neural network (ANN) to management the available energies in a system, utilized depending on the data obtained during monitoring Classic system management. Where the inputs of the steering system are the day, timing, radiation and temperature to increase the management accuracy, as well as the load power to load the required power at all times.by determine the power source or several sources, they are the outputs of the ANN management system

C. System architecture

The proposed approach is to model different energy sources using MTALAB to find the best system management, using artificial neural network (ANN) technology.

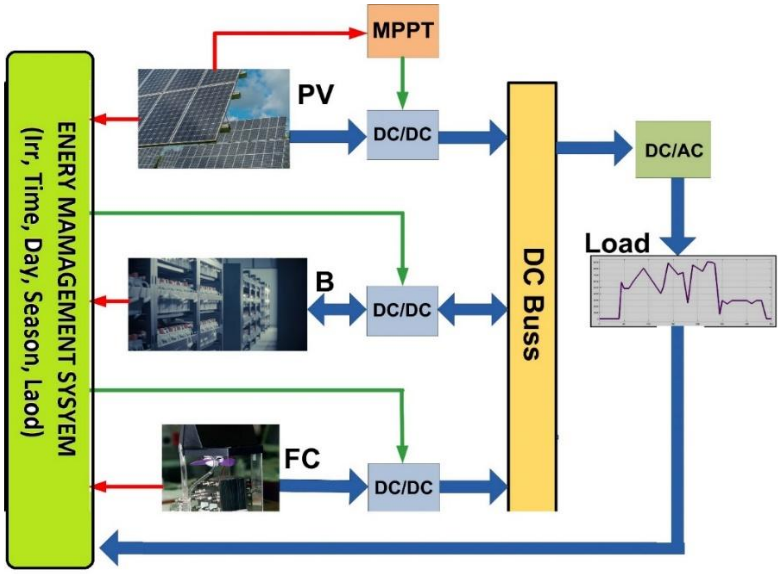

Figure 2. ANN Management

Where System Management It is the operating center in order to meet the demand and supply of power are met by adopting an overall strategy based on external factors and demand forecasting. it includes all solar energy sources, batteries and fuel cells belonging to this system.

D. Training an artificial neural network

Neural networks are trained using learning algorithms rather than being programmed with explicit instructions. This training process allows the network to learn from experience and adapt to tasks. The learning algorithm establishes the configuration of the neural network, which influences its capacity to accurately solve specific problems and provide correct answers.

In this scenario, the system will be trained using external variables depicted in Fig 3 as inputs.

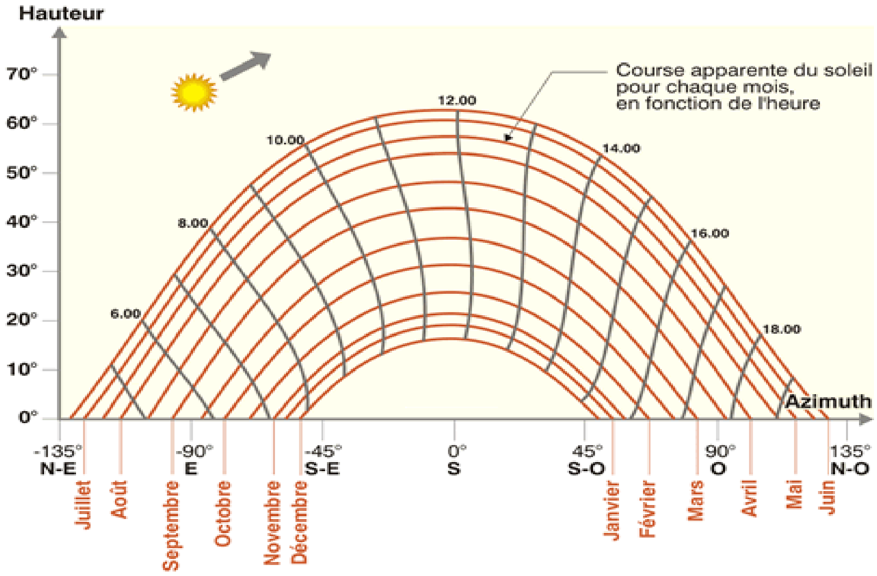

Figure 3. ANN Management

Table 1 presents the input and output variables used in the ANN-based energy management system. The model integrates various energy sources, including PV, fuel cell (FC), battery (Bat), and electrolyzer (Elec), to optimize energy distribution based on historical data and real-time conditions. The system is trained using external variables such as day, time, irradiation (Irr), temperature (Temp), and load power (Pload), as illustrated in Fig 3. These inputs enable the ANN to predict the most suitable energy source to supply the system under different operating conditions. The outputs, shown in Table 1, indicate which energy source is activated depending on the demand and environmental conditions. For instance, when irradiation is high, the PV system contributes to energy supply, whereas during low irradiation or nighttime, the fuel cell or battery may take over. This intelligent management approach enhances system efficiency by optimizing the utilization of available energy sources while ensuring continuous power supply. Fig 4 further illustrates the decision-making process based on past operational data and learned patterns.

TABLE 1.inputs and outputs by ANN management

Inputs					*Outputs*			
day	*time*	*Irr*	*Temp*	*P load*	*Ppv*	*P Elec*	*P F-C*	*P Bat*
6	*0*	*0*	*29*	*1500*	*0*	*0*	*1*	*0*
6	*9*	*230*	*29*	*2200*	*1*	*0*	*0*	*0*
6	*12*	*800*	*39*	*4700*	*1*	*1*	*0*	*0*
4	*4*	*0*	*2*	*1700*	*0*	*0*	*0*	*1*

Inputs					***Outputs***			
day	***time***	***Irr***	***Temp***	***P load***	***Ppv***	***P Elec***	***P F-C***	***P Bat***
5	***1***	***0***	***2***	***1900***	***0***	***0***	***1***	***0***
1	***10***	***85***	***13***	***3900***	***1***	***0***	***0***	***0***
1	***15***	***385***	***18***	***4300***	***1***	***1***	***0***	***0***

Where Irr is irradiation, PFC is fuel cell power, Pbat is battery power, and Pelc is electrolyzer power.

When: if $P_{PV,Battrey,Full\ cell}$ 1=1;this source is It feeds the system if PELECTROLYSE 1=1; electrolyse is charged

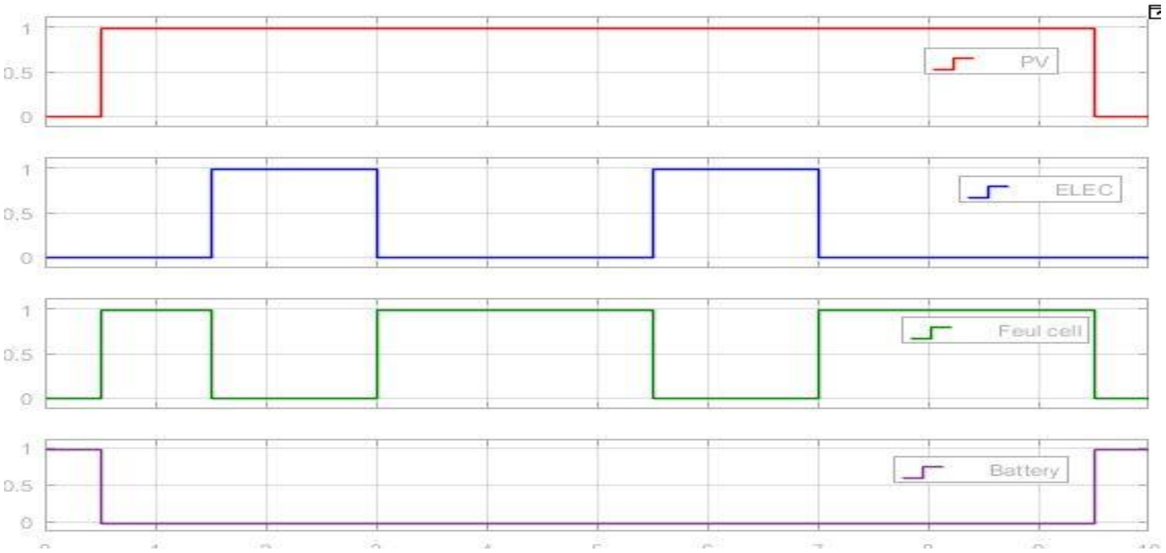

Figure 4. Different energy sources in the system

III. SIMULATION AND RESULTS

Fig 5 and 6 show how different energy sources respond to meet the load demand on a cloudy winter day with peak consumption. Despite the reduced availability of solar energy, the system efficiently balances the energy supply by relying on alternative sources.

Fig 7 provides a similar analysis while also displaying the key input variables used by the energy management system.

In contrast, Fig 8 illustrates system behavior on a sunny winter day with maximum load, highlighting the increased contribution of solar energy to the overall power supply.

The simulation results demonstrate the system's ability to adapt to changing energy availability. During winter, when cloud cover limits photovoltaic (PV) output, the system compensates by optimizing the use of other energy sources to ensure a stable power supply.

Fig 9 and 10 present the system's response on a cloudy summer day with high load demand, along with the corresponding input variables.

Lastly, Fig 9, 10, and 11 show how the system operates on a sunny summer day with peak load, making full use of solar energy while efficiently managing other resources.

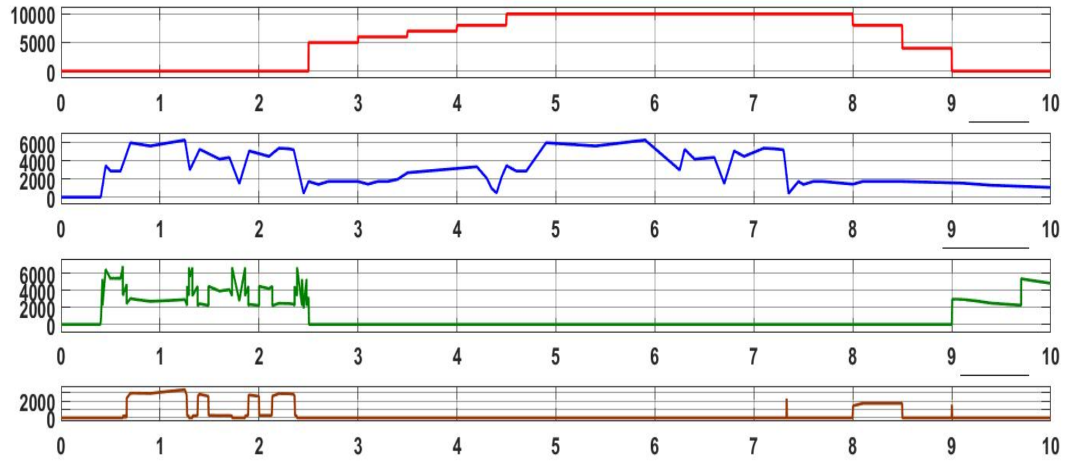

Figure 5. Output in Maximum load on a cloudy day in January 01.

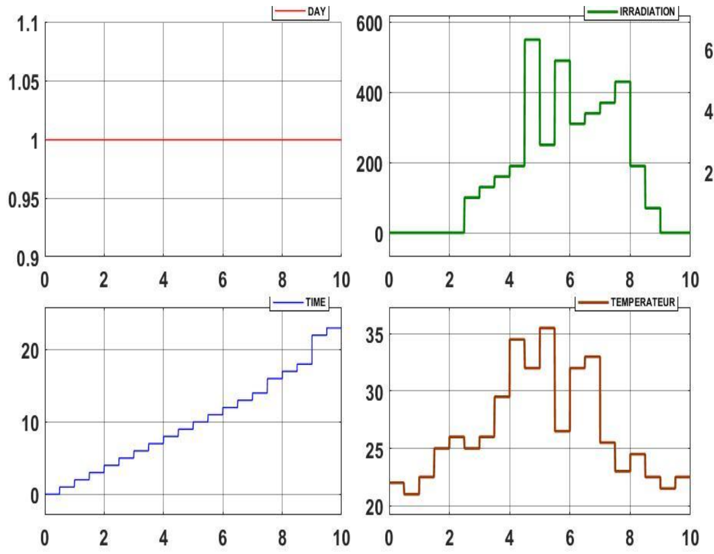

Figure 6. inputs in Maximum load on a cloudy day in January 01.

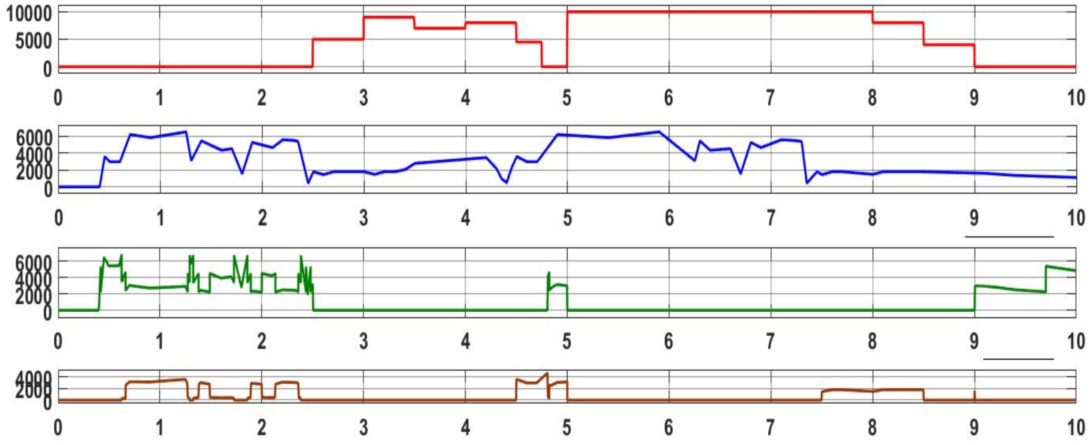

Figure 7. Maximum load on a sunny day in January 01.

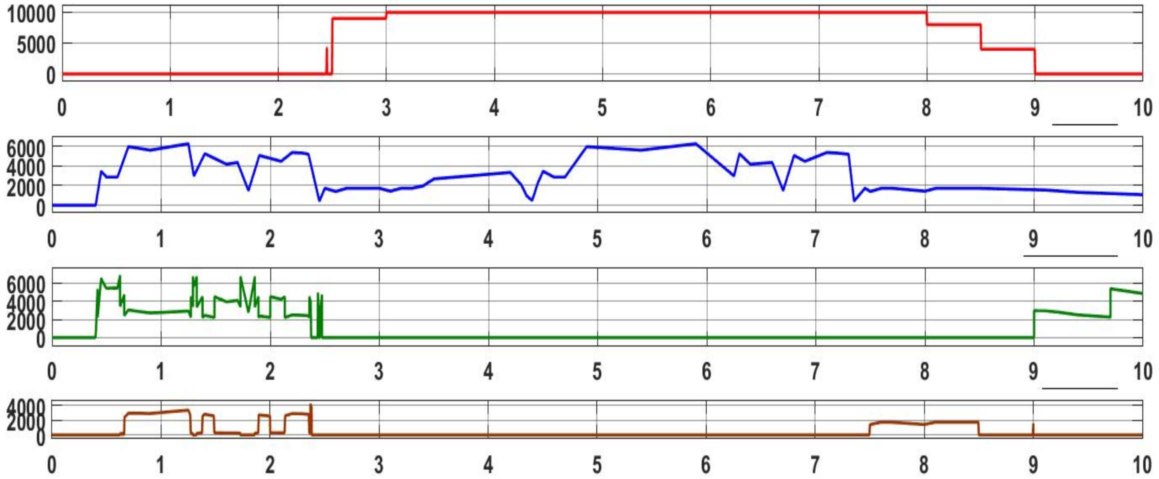

Figure 8. Different energy sources in the system.

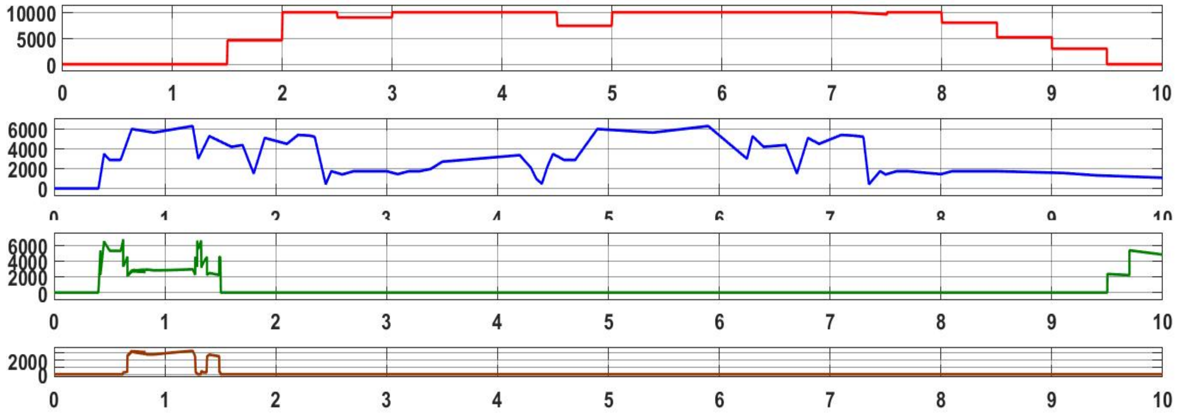

Figure 9. Maximum load on a cloudy day in June 01.

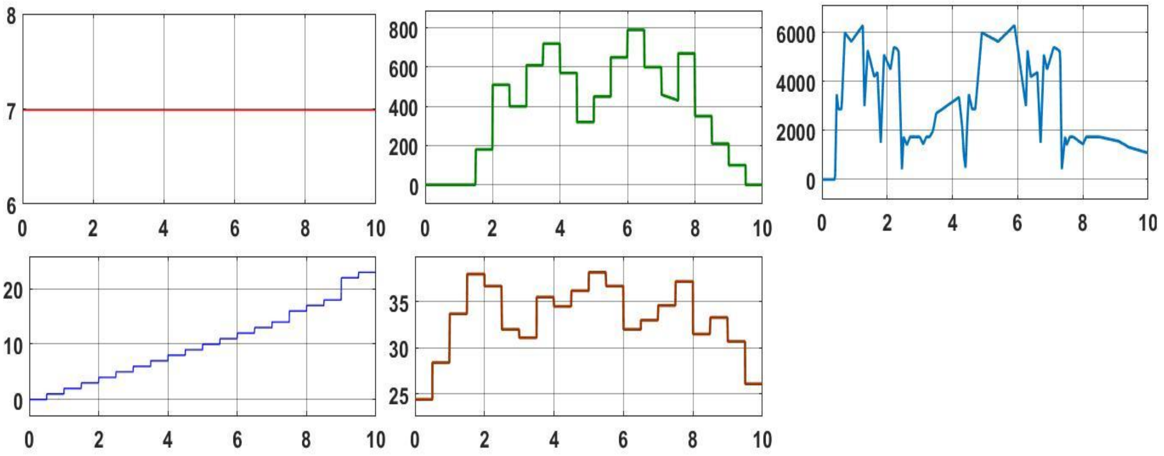

Figure 10. Maximum load on a cloudy day in June 01.

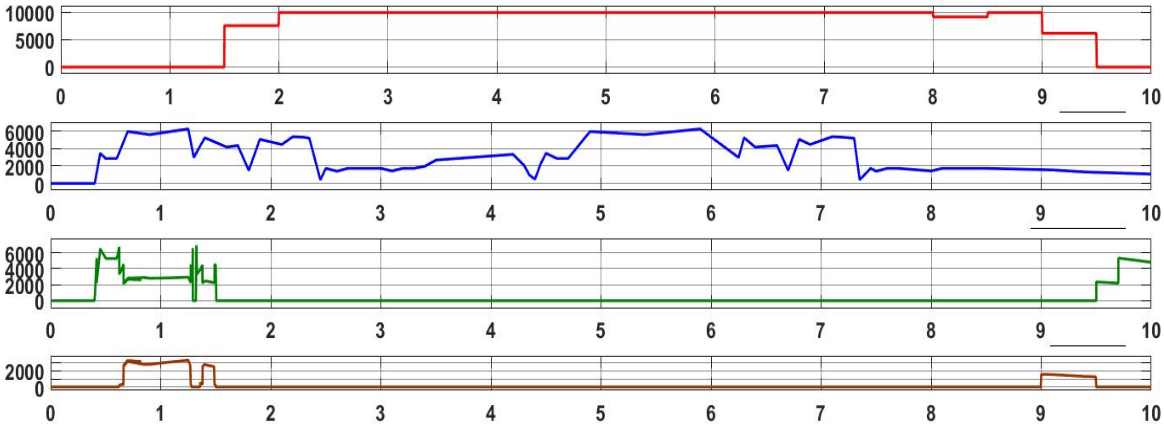

Figure 11. Maximum load on a sunny day in June 01.

The simulation results indicate a positive correlation between energy availability and system performance during summer months. However, it is noteworthy that while increased radiation levels contribute to potential energy gains, the elevated temperatures adversely impact the efficiency of solar panel output. Further exploration of mitigation strategies to enhance performance under such conditions would be beneficial.

IV. CONCLUSIONS

This article discusses an advanced technology designed to optimize for management a solar system, enhancing its efficiency under various conditions. While certain components of the system have undergone modifications, these changes have not significantly enhanced its overall performance. To address this, this work assessed an artificial neuron based on established network regulation techniques found in the literature. By replacing traditional methods with artificial intelligence, the system achieved remarkable improvements in response speed and energy output. As a result, the energy needs of the system can be effectively met across different scenarios.

ACKNOWLEDGMENT

The authors thank Hassiba Benbouali University of Chlef, LGEER, SSAIL, UDES, and CERIST for their support and collaboration. Special appreciation to colleagues for their valuable insights

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