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# ANNs Based Unit for Power Control in a Micro Data Center

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***Abstract*** *- Due to climate change, energy efficiency matters, many innovation stratégies converge to integrate renewable energy sources to deal with. In this paper, we are interested in studying a hybrid System composed of a photovoltaic generator, a diesel generator, and a storage battery destinated to insure a redundant power utility for a Micro Data Center. We developed a powerful control unit based on Artificial Neural Networks technology ANNs, in order to manage the power feeding for this sensitive load.*

**Keywords —** *Micro Data Center, ANNs, Hybrid PV System, FPGA, Energy efficiency.*

## I. INTRODUCTION

In remote locations such as villages, islands, and hilly areas, there is a possibility of frequent power failures, voltage drops, or power fluctuations due to grid-side faults [1]. The renewable energy revolution is advanced as a solution to all of our problems related to the production of electrical energy, particularly the energy photovoltaic (PV), based on the conversion from Solar radiation into electricity based on PV cells. The interest in Photovoltaic (PV) systems has grown rapidly over the last decade because of many advantages: it is a global power source, pollution-free, noise-free, easy to install, it is possible to convert installed and/or incorporated into buildings [2].

The limitation of using PV generators consists mainly of the restricted availability of solar energy throughout the operation period. Therefore, it is substantially recommended to use backup power sources such as batteries and diesel generators to cope with this deficiency [3]. Hybrid systems for renewable energies are defined as energy systems that combine two or more energy sources. When they are integrated, they help overcome the limitations inherent in the use of a single energy resource. The performance of a hybrid system, its efficiency, and service life are influenced, on the one hand, by its design, in particular the architecture, the dimensioning of the components, and, on the other hand, by choice of operating strategy for the various components.

Nowadays, hybrid systems are being presented around the world, both in northern and southern countries, as an alternative for decentralized power generation. The craze is real, but the dimensioning and control of these systems is a lock that must be lifted to promote their development. Our work on the study and experimental analysis of PV/Diesel hybrid systems with storage used to To be used to provide an autonomous and redundant power supply for a Micro Data Centre set up at a remote site (small institution attached to a Moroccan university or public body), is in line with the development of an efficient and stable control tool for the smart management of this type of system.

## II. STUDIED SYSTEM

### A. Hybrid System Overview

In the hybrid systems composed of PV/DG, the PV system reduces the generator's operating time, diesel consumption, and operating and maintenance costs. The operating regime depends on the Micro Data Centre energy demand (PLoad), on the one hand, and on the state of charge (Soc), of the battery and the output of the PV (Ppv) field on the other hand.

The bloc diagram Fig.1 shows that the microdata center (Load) is mainly powered by the power delivered by the photovoltaic cells.

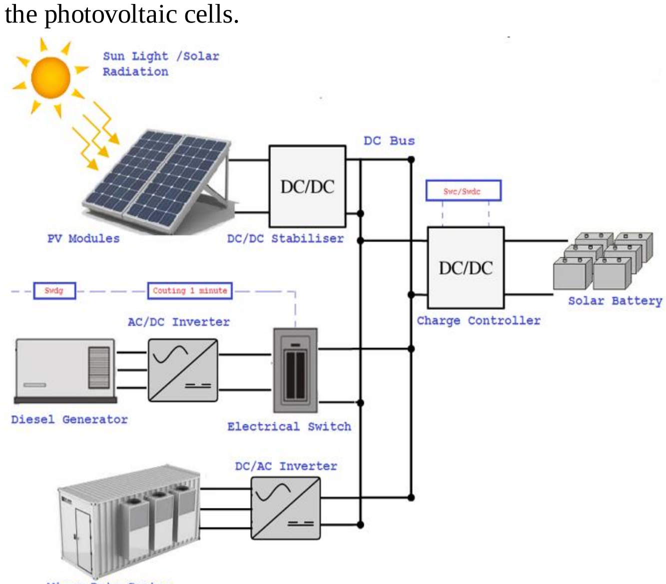


**Fig. 1 The Hybrib System Block Diagram**

Photovoltaic cells are composed of several parallel-connected silicon cells. They collect solar energy and convert it into electrical current. This conversion is carried out by converters, which regulate the voltage and current output of these solar cells [4]. Lead-acid batteries [5]. are used in the model to store excess energy produced by the PV solar system and diesel generator [6]. On the contrary, when the energy produced is not sufficient, the battery discharges. The solar controller prevents the battery from being overcharged and discharged too deeply. Alternatively, a DC/DC converter (MPPT " Incremental conductance" [7]) can be used to operate the PV field at its maximum PowerPoint. The implementation of a DC-DC converter offers high gain [8]. The converter is fed from solar Photo Voltaic (PV) appropriate for DC microgrid. The hybrid system can work automatically if a diesel generator starts and a stop system is added. The missing energy can be supplied at any time by the generator.

### *B. Hybrid PV System Operating Modes*

The system studied ensures the power supply according to two operating modes:

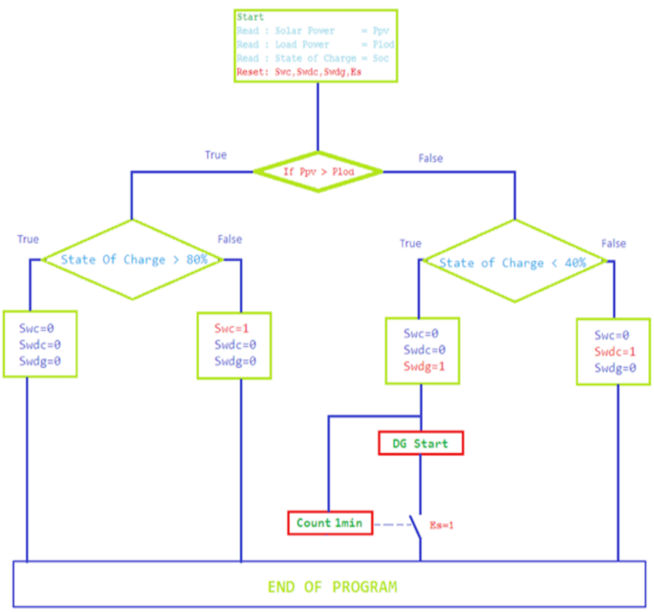


**Fig. 2 The Hybrid System Operating Algorithm**

***a) Normal mode (Sunny):*** During this mode, the Micro Data Center is powered directly by the Power Ppv delivered by the PV cells, being sufficient to ensure proper operation (during the sunny day), the control unit checks the state of the charge (Soc) - if the Soc is higher than 80% - the Swc, Swdc, Swdg switches are set to 0, the storage batteries remain intact, also the DG generator. If the Soc is less than 80%, the Swc switch is set to 1 to ensure the batteries are connected; in this case, the PV cells supply the Micro DC and also the batteries.

***b) Emergency mode (cloudy days and night):*** When the available solar radiation is insufficient to support the load required by the MDC (nights or cloudy skies), the control unit checks the state of the load, if the SoC is higher than 40%, the Swdc switch is set to 1, in this case, the MDC is powered through the storage batteries, If not (Soc < 40%), the control unit starts the DG by setting the Swdg switch to 1, the air-conditioning system is connected directly to the DG, after 20 minutes of its start (the time the DG reaches its operating point), the electric switch Es.

## III. HYBRID SYSTEM COMPENENTS

### *A. Micro DC (Load) Caractéristiques*

The modular data center replaces the traditional data center legacy by providing flexibility, scalability, portability, reusability, a smaller footprint, reduced deployment time, increased efficiency, and lower total cost of ownership. It is designed as self-contained [9].

Table 1. details the components of the Micro Data Center and gives a global view on the power consumed at full load

**Table 1. Power consumption of the Micro Data center.**

| Equipement | Reference | Temperature | Voltage | Power Supply |
|---|---|---|---|---|
| Access Control server | ZYCO O EX16S | 0 -- 45° Celsius | 227.3 V | 25W |
| ATS | TCS2P 125 | -20 -- 60° Celsius | 220 V | <1W |
| 24 port Switch | CISCO ME380 0X | 0 -- 45° Celsius | 220 – 240 V | 210W |
| Hypervisor 1 | Power Edge R740 | 0 -- 45° Celsius | 227.3 V | 750W |
| Hypervisor 2 | Power Edge R740 | 0 -- 45° Celsius | 227.3 V | 750W |
| UPS | Eaton 5PX 3000 | 0 -- 40° Celsius | 220 V | 987 W |
| Cooling System N+1 | MMC Combined Cooler | -20 -- 60° Celsius | 220V | 6 KW |

### *B. Neural Network the Control Unit*

PV systems are subject to various faults and abnormalities during operation, which can reduce their efficiency and productivity [10]. Neural Networks have substantially become the dominant artificial intelligence (AI) approach for a variety of domains such as climate change problems [11] and also ANNs for the water resource field [12]. The aim of AI is to emulate the human brain and build systems that can operate smartly and autonomously [13].

In our case, the Neural Network technique is used to improve the Hybrid PV system energy efficiency. Neural

Network représente a powerful control unit for the Photovoltaic generator.


**Fig. 3 The Input/Output of The Unit Control**

The sensitivity of the data processed in the microdata center means that fault tolerance must be minimized. As shown in Fig3, the artificial intelligence technique controls Input/Output; in such an isolated grid, the integration of a Neural network controller maximizes the size of the PV power plant and minimizes fuel consumption, maintaining the quality of service 24 hours a day, 7 days a week.

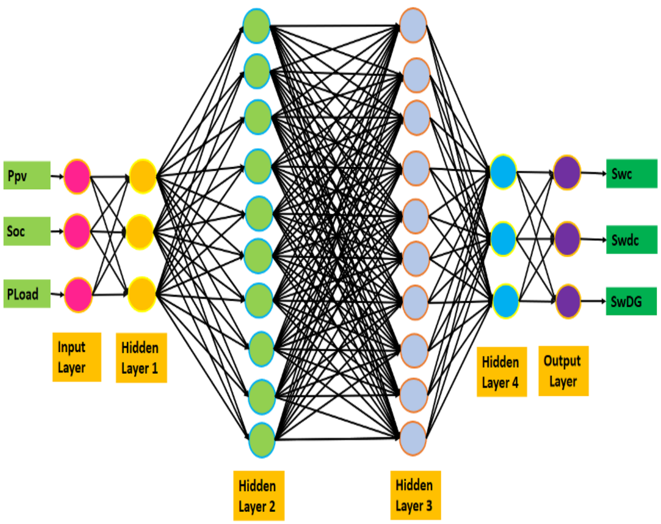


**Fig. 4 The ANNs Architecture**

The most common type of Artificial Neuron Networks (ANN) is the Multi-Layer Perceptron (MLP). MLPs organize their nodes into layers (input, hidden, and output), and training is performed with a gradient-based algorithm called backpropagation [14]. The Fig. 4 and Fig. 5 show the intern architecture of the ANN on which our control unit is based.

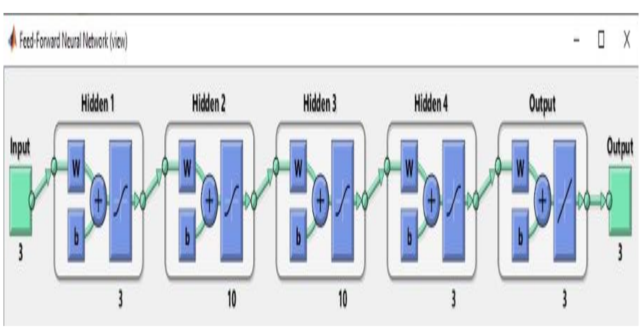


**Fig. 5 ANNs Input/Output and Hiden Layers**

The network developed in this study consists of four hidden layers, and one output layer, activation function tanh function [15], [16] was chosen in the hidden layers and the pure-line function [17] In the output layer. These choices allowed us to reach a perfect convergence of the Artificial neural network.

## IV. RESULTS AND DISCUSSIONS

### A. *The Artificial Neural Network Training*

The architecture of artificial neural networks is trained. The choice of architecture, type, and parameters of the membership function takes into account the computing resources of the tool and taking into account the type and amount of information that is coming to the input of an artificial neural network [18] **-** [26].

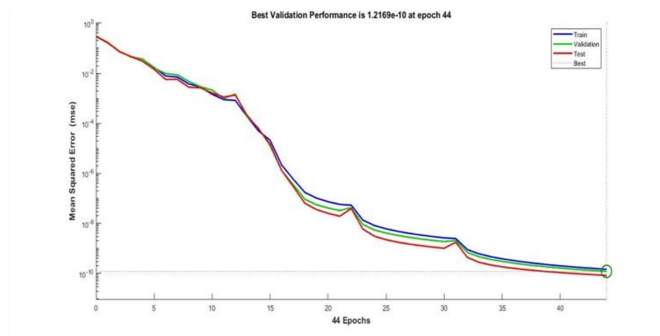


**Fig. 6 The Artificial Neural Network Training Curve**

Fig.6 shows the training quality of our artificial Neural Network, where we notice that the training curve and the test and validation curve are almost identical, the error (MSE) goes down to $1.21*10^{-10,}$ which shows that the training is done in a very good way.

### B. *The Hybrid PV System Control Unit Performances*

In this section, we will analyze the efficiency of the PV system control unit. We distinguish two scenarios that can be encountered: the first one when the state of charge of the battery is higher than 40% and the second one when the Soc is lower than 40%, with variable photovoltaic power.

***a) Scenario 1 : Soc > 40%***

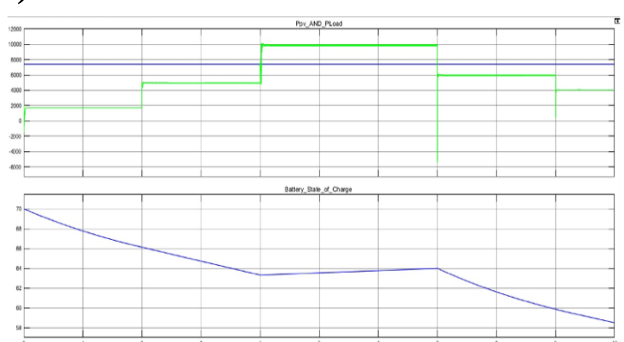


**Fig. 7 Scenario 1: Soc higher than 40%**

In case when the Soc is higher than 40%, with a power demand from the microdata center (Pload) exceeding the power delivered by the PV Hybrid system (Ppv), the control unit ANNs controls the Swdc =1 so as to ensure the power supply of the MDC through the battery as the main source, Swc, and SwDG maintain their states = 0 (as shown in Fig. 8 Scenario 1 Resulting)

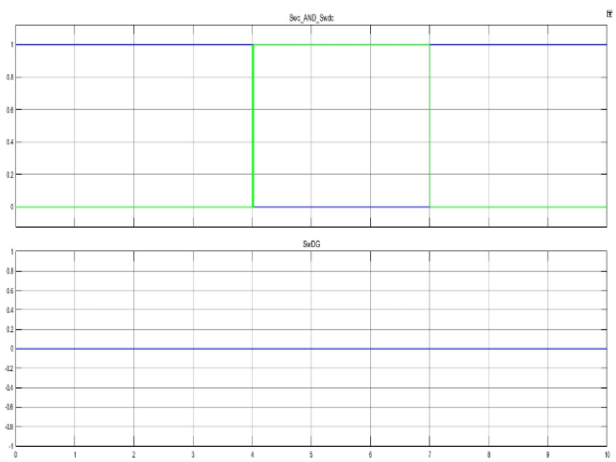

**Fig. 8 Scenario 1 Resulting**

If the Ppv exceeds the power threshold requested by the MDC, During full sunshine, our ANNs change the switch state to Swc=1 (The battery starts charging). Swdc and SwDG are set to zero.

***b) Scenario 2 : Soc < 40%***

During this scenario, while keeping the same operating conditions, i.e., power Ppv < Pload (cloudy days and nights), if the Soc is less than 40%, in this case, the PV generator is unable to power the MDC.

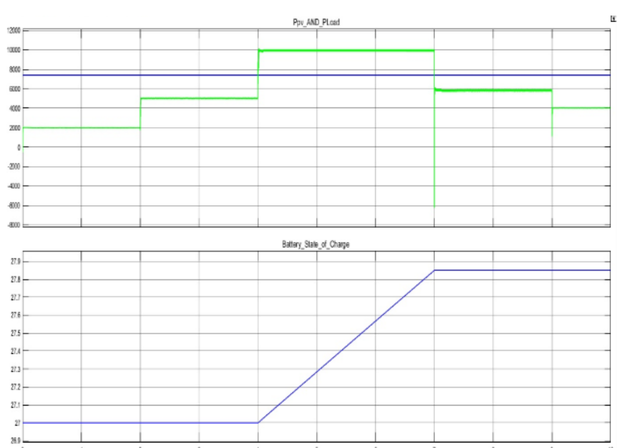

**Fig. 9 Scenario 2: Soc Lower than 40%**

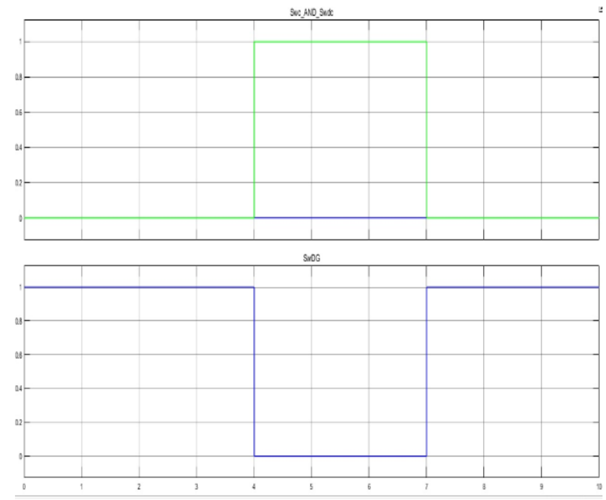

**Fig. 10 Scenario 2 Resulting**

The ANN control unit readjusts the parameters (Swc= 0, Swdc=0), the Diesel Generator takes over to supply the MDC, SwDG=1, and it can be seen that the role of the DG is indispensable during this period. (as shown in Fig. 10 Scenario 2 Resulting).

## V. CONCLUSIONS

The energy consumption of data centers has become one of the major issues in terms of energy efficiency over the years. The impact of these infrastructures on the global energy plan is therefore not without value. Thus, many researchers have focused on developing systematic knowledge, tools, and standards to reduce the consumption of data centers and to integrate renewable energy into their energy portfolio.

In the same vein, it has presented through this study a robust and intelligent control tool based on ANNs, capable of managing the operating regime of a PV Hybrid system used to power a large and highly sensitive technological infrastructure such as a Micro Data Centre.

During the test and simulation phase, the control unit developed, proved its stability and relevant reactivity to changing conditions. This study will be generalized through a proposal for an autonomous system dedicated to the power supply and supervision of the operations of a Data Centre with higher energy consumption. The system is currently under development in the case of Hassan 1st University Morocco, and the data aggregation will always be Artificial Intelligence-based.

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