International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 24 (2015) pp 43983-43992

Designing a photovoltaic generator with intelligent controllers applied to a breeding Building Hens Layers

F. Bekkouche,

Maître Assistant A Department of Electrical Engineering, Faculty of sciences & technologia, University of Mostaganem, fboutlilis@gmail.com

H. Ait Mimoun,

PG Scholar, Department of Electrotechnical, Faculty of Electrical Engineering, University of sciences & technologia Oran, Hamiche.ait1@gmail.com

B. Bekkouche,

Professor, Department of Electrical Engineering, Faculty of sciences & technologia, University of Mostaganem, benbekm@yahoo.fr

Abstract

Currently the world's consumption of electrical energy is seeking a diversification of energy sources, a truth that speaks louder than ever the development of renewable energies.

This work focuses on the use of photovoltaic in the hen laying barns ORAVIO of Tiaret (poultry Regional Office West).

The primary objective of this study is a possible contribution to relieving the national grid in the Central Highlands who suffers his last years in the quality of energy services through the design of a photovoltaic generator (GPV) with a MPPT control for optimization of the energy consumed.

The second objective is the fuzzy control of livestock buildings climate to improve the overall output gain. Reducing the number of switching increases life span of equipment and the reduction of the operating time produced a significant gain in energy consumption.

Keywords: Design - Photovoltaic Energy - laying hens - Fuzzy Logic- MPPT- Switching - Gain.

Introduction

Energy is the basis of all human activity. Today, much of the global energy demand is assured from the limited reserves of fossil fuels. Some developed countries have turned to nuclear power, while the latter presents risks of serious accidents.

The production of electricity through a photovoltaic system connected to the network is of great interest to developing countries, especially for countries suffering his last years of network quality of service.

Photovoltaic energy can have clear benefits, especially for its cleanliness and durability. In addition it can be used in various applications such as agronomy and livestock in remote sites.

In this context, the optimal design and integration of renewable energy into the national grid is a contribution to the relief of the latter, particularly in the Central Highlands or is registered in recent years a striking degradation of service quality this network.

This work is a step in a project to design a photovoltaic plant to supply the Oravio Tiaret campus. The campus consists of 40 buildings of 960 m² for laying hens. The dimensioning of a specific photovoltaic field is actually a fairly complex process because there are many parameters to consider, a certain amount of imponderable (meteorology), and especially multiple interactions between choices as consumption elements of the conversion chain add to the receptor to define the total consumption of the system.

Since such a project certainly requires optimizing the consumption of electrical energy to reduce the cost of investment, we are we interested in the climate of buildings. The control of climate variables such as temperature and humidity not precise mathematical model of the process to be controlled and they have strong nonlinearities or inaccuracies.

We will apply this intelligent control (fuzzy logic) in different components of the PV array such as MPPT, the state of the battery charge and control of the climate variables in the breeding building.

Overview of farm building

The building creates a favorable breeding poultry environment, ie to meet their physiological needs. These requirements are determined by the temperature, air velocity and humidity.

At startup, the chicken needs heat (35 ° C), and fears the air currents [1]. The building must be heated properly, clutter-free air intakes. In contrast, the finish Chickens need freshness. In warm weather, high air speed (about 1m / s) level is needed to fight against high temperatures. Thus, the physiological needs of the hen vary during breeding age and season with regard to the building must respond to each request. It is important to properly manage the breakdown by effective control systems.

Ventilation allows good breathing poultry. It shall ensure the elimination of odors and toxic gases, especially ammonia, dust generated by the litter, the heat generated by animals and absorbed by the building [2].

The outside temperature affects food consumption. The latter varies inversely with the consumption which acts on the production of egg [3], [4] and [5].
The humidity promotes the presence and proliferation of parasites. This multiplication leads to the appearance of the lesions and symptoms characteristic of coccidiosis.
Eggs from coccidia or oocysts are released in the digestive tract and then discharged to the outside environment with the droppings. [6]

Impact of commands
The internal climate control a poultry farm building promotes the growth and improvement of nesting efficiency. The building model is a nonlinear equation system with variable parameters. The complexity of livestock building climate process poses several nonlinear problems, nonstationary disturbances having inputs whose powers are greater than those of the actuators. We have designed a system that is not fully controllable.
It is necessary to set achievable guidelines. Use of controls based on linear systems requires a linearization of the process around a working point, which hinders the use of variables at the operating point which itself evolves. If the use of the model horizon is large have to take the non-stationary process into account. Using an adaptive model poses the problem of the wealth of inputs.
Conventional type Boolean commands do not allow for optimization, but they have the advantage of a good robustness with respect to nonlinearities and not stationarities.
It is possible to achieve productivity gains and savings of energy and raw materials through predictive algorithms, optimal, multi variables, these algorithms based on linear models are generally effective only for short periods. There is therefore a need to introduce supervision that allows taking into account the period of operation (day, night, and season).
Fuzzy logic is a good compromise to achieve a practical choice for multi variable control while introducing a supervision that takes into account both the process status and behavior, value disturbance of nesting conditions, etc.
Building control variables are T_i and H_i through the adjustment of heating, ventilation, and humidifier. The external disturbance measurable parameters are the outdoor temperature and the outdoor humidity T_0 H_0.
The use of powerful commands like optimal control, adaptive control or for building climate control requires identifying the best possible system, which is very difficult, given the variation in parameters conditioning the conduct of building climate over the time.
The fuzzy control is a valuable element in the control of easily identifiable or parameters undergo significant variations systems.
Its implementation is done in three steps: fuzzification, inference and defuzzification. This improves the fuzzy control system in a remarkable way:
- An energy saving by optimizing the operating time.

Increased lifetime of equipment by reducing the number of switching operations.

Site selection Tiaret was done for his significant variation in climatic conditions (the highlands of Algeria) and the significant disturbance of the current network of the national electricity and Gas Company that this region sulfurs. So the realization of a GPV to provide good quality service and climate regulation is a necessity for the profitability of farmers of laying hens.

Solar System
A. Synoptic Diagrams
From installation to Oravio Tiaret consists mainly of photovoltaic generators Installed on the roof of the livestock buildings, a bank of storage batteries, a generator and a connection to the MV network (30KV) Sonelgaz. The source selection is done so that the system can continuously provide the site with the energy it needs as shown in Fig.1.

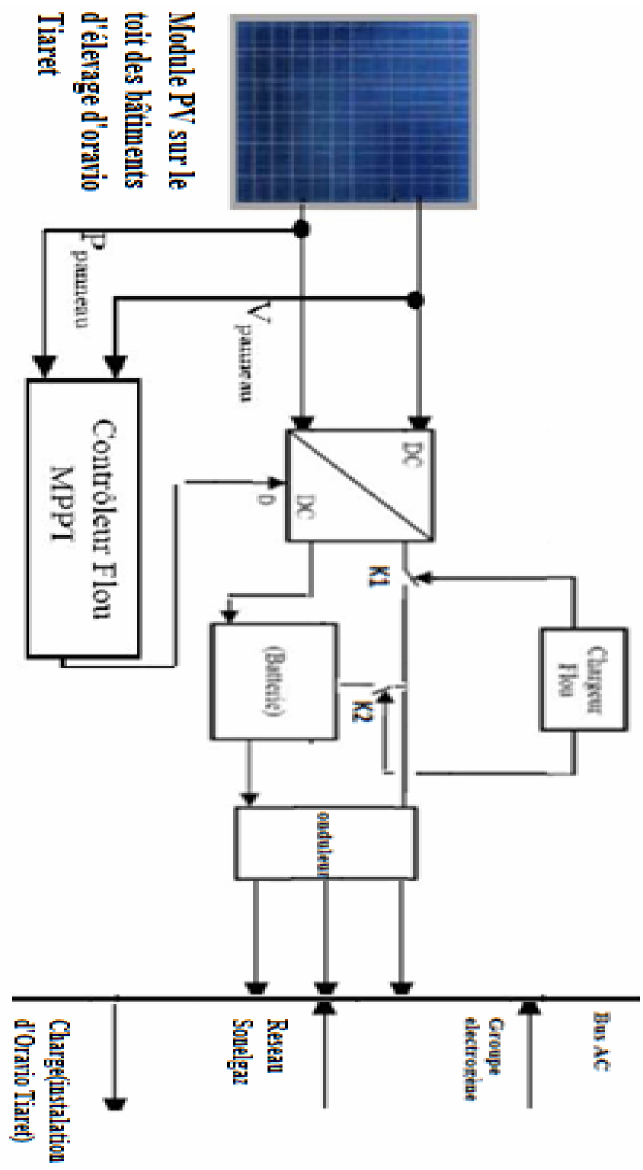


Fig.1. Block Diagram of a Hybrid Photovoltaic System

B. *Maximum power point tracking (MPPT)*

The current-voltage-power highly dependent on the sunshine and temperature, the temperature dependence is further amplified by the properties of the photocurrent and the reverse saturation current of the diodes. That will change the extractable power.

It is therefore necessary that the operating system can be adapted to extract the most power: thus was born the idea of MPPT (Maximum Power Point Tracker [7].

More than thirty methods further proposed PPM (Maximum Power Point) was, but the most prominent is the algorithm (Perturb and Observe) which predominates.

In this paper we propose a concept of MPPT based on fuzzy logic [10, 14] compared to that of P & O (see figure in Annex). This command offers the advantage of being robust and relatively simple to develop control, they are based on real-time observation of two criteria that are the difference E of ∂ P / ∂ V with respect to the desired value (that is to say, 0) and the change in the ΔE standard. Where in a converter is used. These criteria after inference explained in the diagram below fig.2, are used to build a D is the duty cycle of the Boost converter (DC-DC). This value D leads to the determination of the MPPT value every moment.

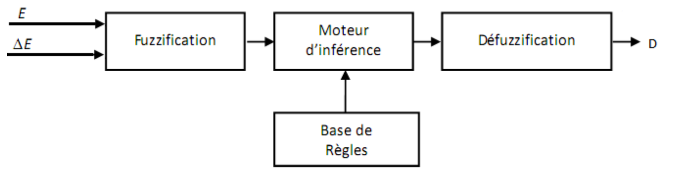


Fig.2. Diagram of the fuzzy logic algorithm [11].

C. Energy Storage

i. Battery

The storage system used for photovoltaic systems is the battery electrochemical storage [12].

ii. Battery Charger

Batteries must always be protected against overloading and deep discharge, it is necessary to add to it a regulator.

Its main function is to monitor the status of the battery. It allows the full charge of the latter eliminating the risk of overload, interrupts the power supply of loads is addressed if the state of charge of the battery falls below the deep anti discharge safety trip point. Thus extending the life of the battery that is the only weak component of the PV array.

We will apply again in this article the fuzzy state of the battery charge [13], as shown in Fig.1.

Simulation and Results

Our application is made on laying hens centers from four identical Oravio Tiaret western Algeria. Each center is equipped with 10 Livestock buildings, 01 generator and connection to the Sonelgaz network 30KV.

A. *Dimensioning*

The dimensioning of a specific photovoltaic field is actually a fairly complex process because there are many parameters to consider, a certain amount of imponderable (meteorology), and especially multiple interactions between choices as consumption elements of the conversion chain add to the receptor to define the total consumption of the system. The choice of these parameters depends on the size of the photovoltaic field, itself determined by consumption.

i. Location, geographical and continental:

- *Latitude: 35 degrees 12 minutes north,*
- *Longitude: 1 degree 15 minutes east,*

ii. Climatic situation

The climate of this region is semi-arid and it is sunny with an average annual solar radiation of 1722,8 Kwh / m2. The annual average temperature is 29 ° C; in summer it can reach 40 ° C in winter and drops to 4 ° C. Heat waves and winds of sand in this region are temporary.

iii. Estimation of daily requirements

A socio professional study was done to meet the daily consumption site which not only depends on the needs of the livestock buildings, but also the energy consumed globally by the company.

Energy consumed per month for each center (Sonelgaz billing) is:

Ec = 2503Kwh / d

Data were recorded in Algeria Solar atlas for the calculation of the peak power (Pc) and the choice of the number of modules that one should have.

The sizing calculations [14] for each center have led to the following characteristics:

GPV:

Pc = 79.3KW

Number of units = 260

iv. Fashion connection

Branches in parallel = 52

Serial Module = 5

Type SunPower SPR-305-WHT

v. Storage

A batch of 55Batteries 1923 Ah 48V (11 parallel branches 5 batteries in series), which will make a total of 21 153 Ah for an autonomy of 4 days, 24 hours / 24 hours.

vi. The converters

In order to adapt the shape of the electric power supplied by a component of the installation according to the intended application, a converter it will be necessarily connected. [18]

The converters are key in terms of energy efficiency and reliability. In the case of a photovoltaic generator role is not limited to transform the voltage and current (DC) generated by the PV panel, but also includes the PV array to operate at its maximum power point. Moreover, the inverters must ensure reliable network monitoring to protect against failures and cuts off power in case of network errors.

However, the DC-DC converter (parallel, Boost) employed is characterized by its cyclic ratio D between 0 and 1, which gives the time of opening and closing of the transistor [17].The equivalent electrical circuit is show in annex2.

Indeed, the photovoltaic panels are subject to changing conditions in terms of sunshine and temperature which modifies the extracting power. So to extract the maximum possible power, the converter builds a D value (fuzzy logic) is the duty cycle of the DC-DC converter. This value D leads to the determination of the value MPPT every moment [8]. Boost to use SMA's manufacturing technology, type Sunny Island.
The PV panels of running continuously develop, we must install inverters whose role is to inject solar energy transformed into the low voltage grid of 380... 400 V at a frequency of 50 Hz. The inverter is used for manufacturing SMA technology, type Sunny Mini Central 6000A (SMC6000A). As WB6000, SMC6000A will be installed in the same manner.
The simulation was performed under Matlab / Simulink shown in Annex 1.

B. Maximum Power Point, fuzzy logic

The three variables (E, EC and D) are described by the figures.2 and the inference by the matrix Tableau.1

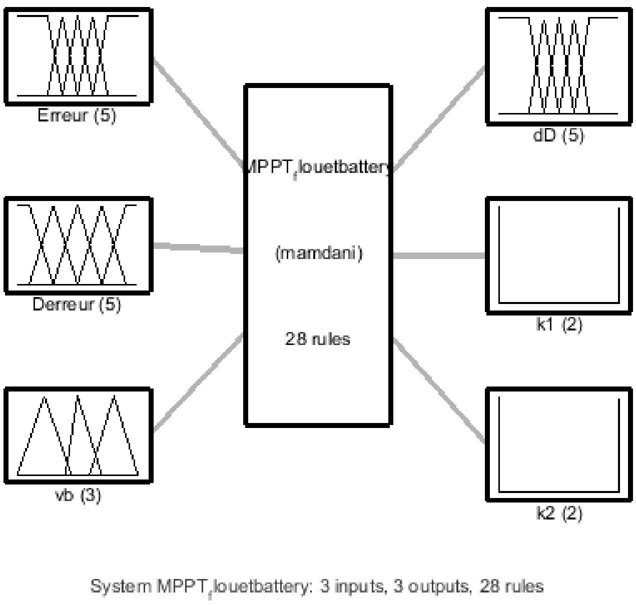


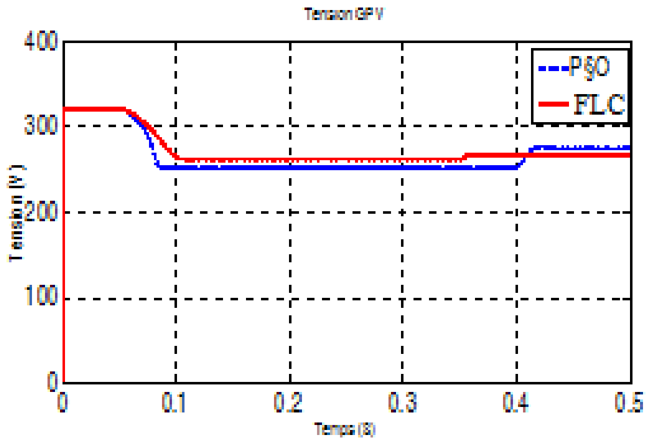
Fig.3. Fuzzy Controller: MPPT and Battery Management (Variable Membership Function)

Table.1. Table of Inference Fuzzy Controller MPPT

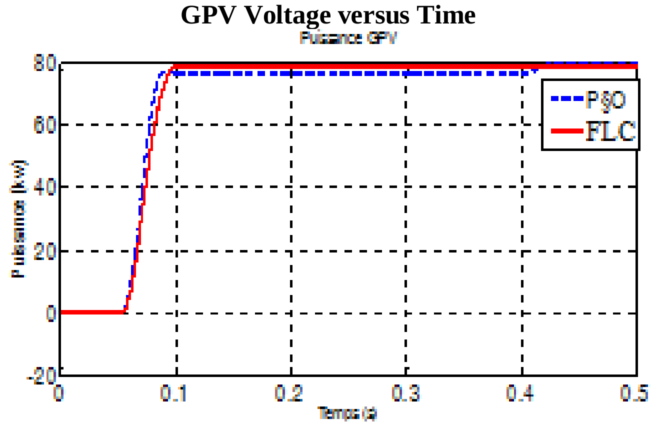
E↓ ΔE→	NB	NS	ZE	PS	PB
NB	ZE	ZE	PB	PB	PB
NS	ZE	ZE	PS	PS	PS
ZE	PS	ZE	ZE	ZE	NS
PS	NS	NS	NS	ZE	ZE
PB	NB	NB	NB	ZE	ZE

We start analyzing the results with a presentation of our variable outputs designed photovoltaic generator and voltages delivered to the load to operate the GPV.

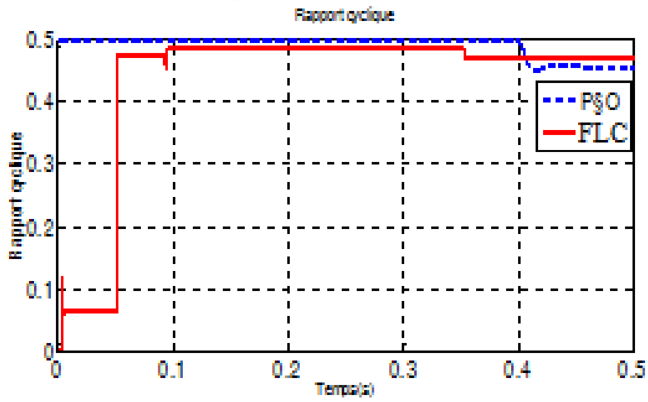
The graphs of Fig.4 present the input signals and outputs of the fuzzy controller compared with those of conventional P & O (perturb and observe) [11].



GPV Voltage versus Time



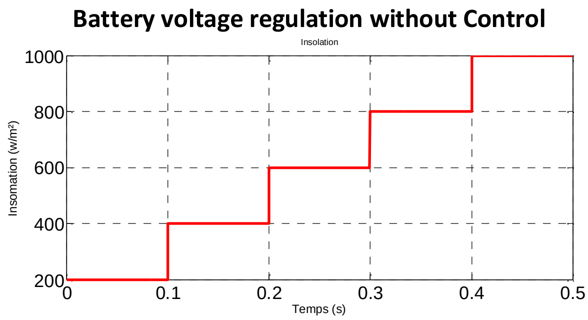
GPV Power versus Time



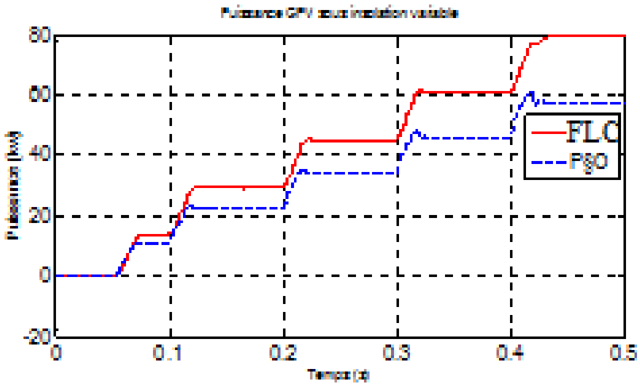
Duty cycle versus Time

Fig.4. Simulation results of the boost with fuzzy MPPT compared to P and O

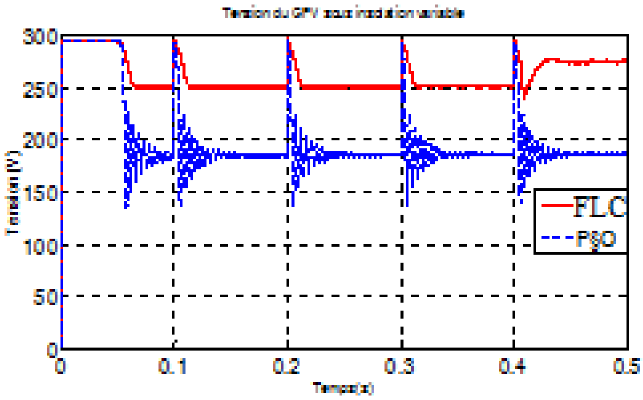
According to the results of figure 4, we see the effectiveness of the chosen algorithm MPPT. The response times of the transients are very acceptable especially for the application to which we interested Oravio Tiaret where the maximum power is reached in 0.1s.
To validate our algorithm, we tested our controller for various sunshine values Fig.5.



Sunshine versus Time



GPV Power under Variable Sunshine



GPV Voltage under Variable Sunshine

Fig.5. Simulation Results of (Boost) with fuzzy MPPT for different values of Sunshine

The simulation results obtained in fig.5 show again the efficiency and robustness of the controller to produce the maximum power from the photovoltaic generator array and follows the instruction whatever variations of sunshine (79.04kw for 1000 w/m² and 60kw for 800w/m² sunshine).

These results are acceptable in terms of system stability. The shape of the signals delivered by the PV generator confirms the effectiveness of the fuzzy controller compared to the conventional P & O.

C. fuzzy Charger Battery

The batteries are very sensitive elements and their destruction is easy. In what follows, we propose a smart (fuzzy) battery controller where the input is Vb battery voltage and outputs K1: control signal Switch 1 between PV generator and battery [0,1] K2: control signal Switch 2 between the battery and the load [0,1] (Fig. 3).

When the insulation changes, the voltage delivered to the load with fuzzy controller varies in a range of value between 503.8 and 504.6 V, and reaches a value of 589.5 as the battery function without regulation fig.6.

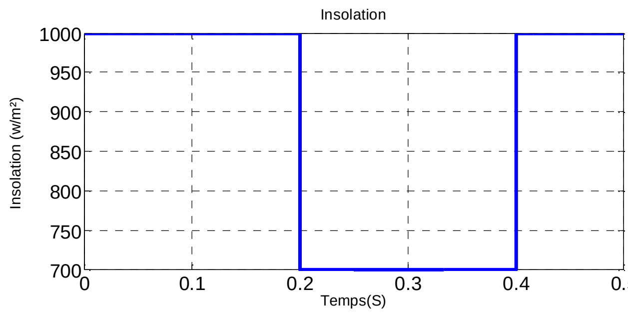
We infer from this result that the influence of the voltage regulator load is in a maximum, since it maintains the tension in a range that protects the battery.

Simulation results with respect to the injection of the power network according to the model presented in annex1 are given by the features of the Fig.7.

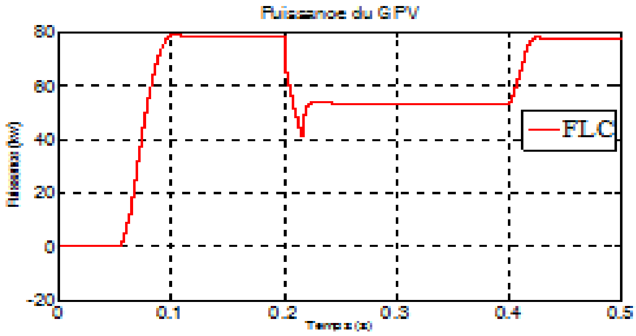
These are very acceptable to the particular steady state (permanent) or the frequency of 50 Hz is observed, the effective amplitude of 380V between phase and an effective current of 120A with perfectly sinusoidal waveforms following the adjustment of the connection filter.

Transient active power reaches the value of 170kW, which is the sum of two powers (PV generator + battery) before the intervention of the controller battery.

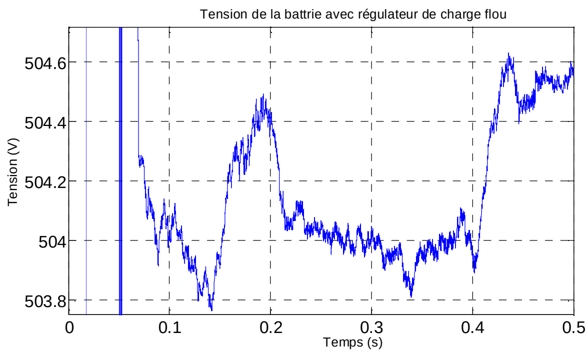
The same behavior is observed with the current effective value of 260A, which confirms the effectiveness of the advantage of fuzzy controller load selected.



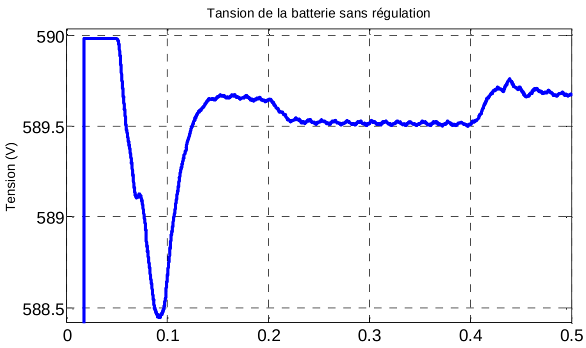
Sunshine versus Time



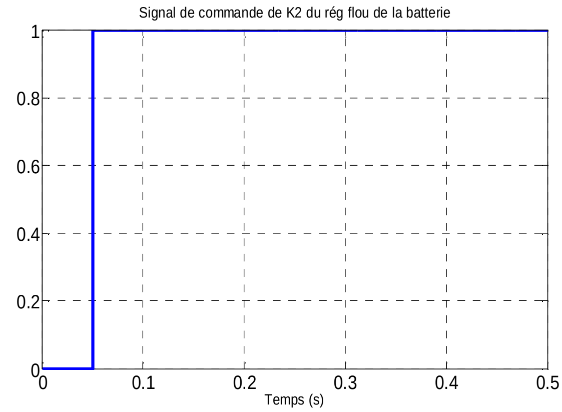
GPV Power versus Time



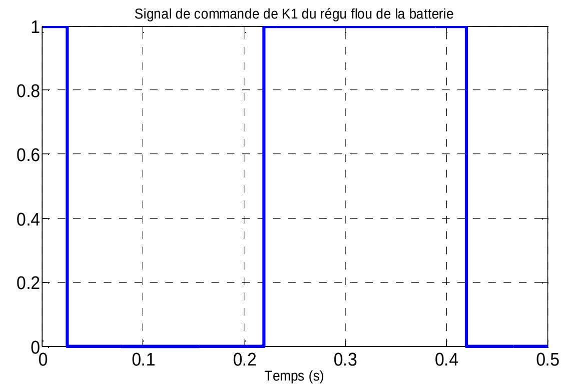
Battery Voltage with Fuzzy Control



Battery Voltage Regulation without Control

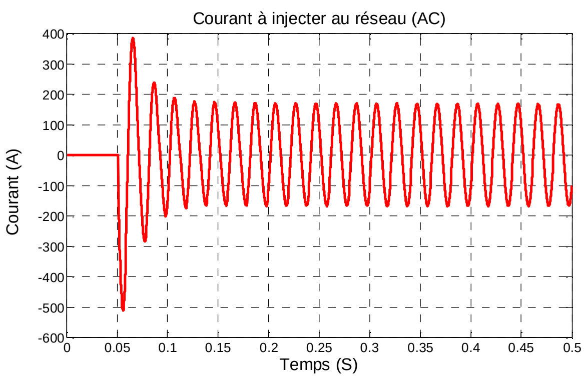


Signal K1 Control

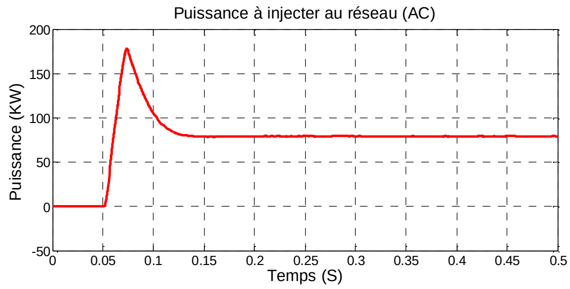


Signal K2 Control

Fig.6. Simulation Results (Fuzzy battery charger)



Current to be injected to the Alternative Grid



Power to inject to the Alternative Grid

Fig.7. Results of Simulation of the Injection to the Grid

Climate Control Building breeding

Our work is based on the model of the barn oravio Tiaret. The latter is a non-linear model to be controlled by two fuzzy controllers, one for temperature, the second for moisture, as shown in fig.8.

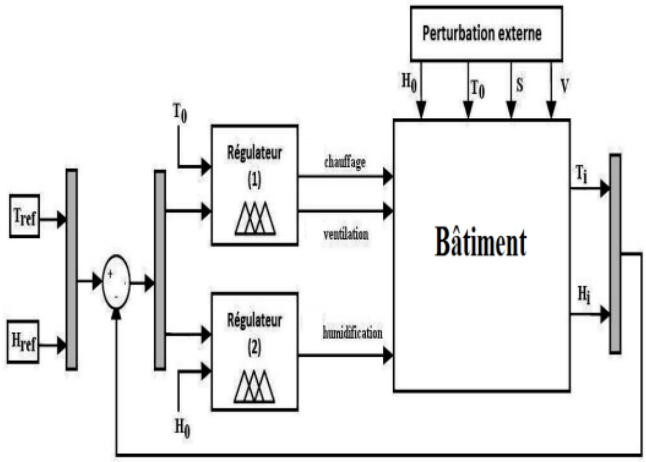
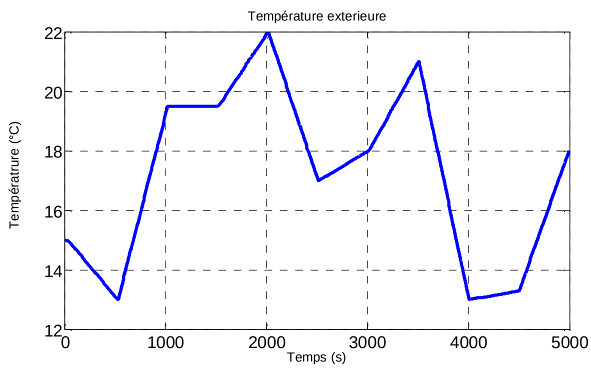


Fig.8. Fuzzy Controller of Building Climate

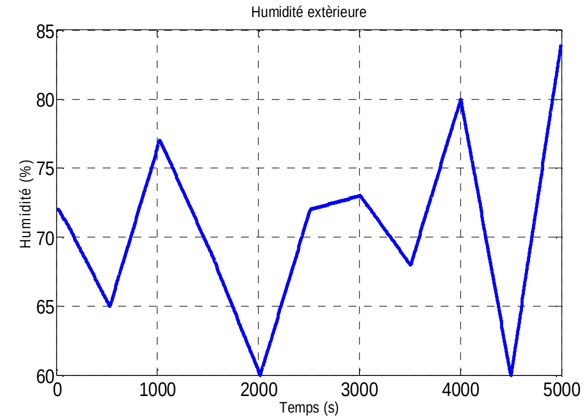
A. Simulation and results

Fig.9. above shows the two inputs of each of the two controllers in the system.

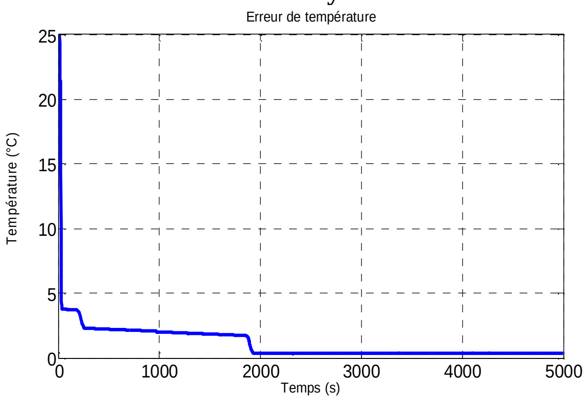


External Temperature versus Time

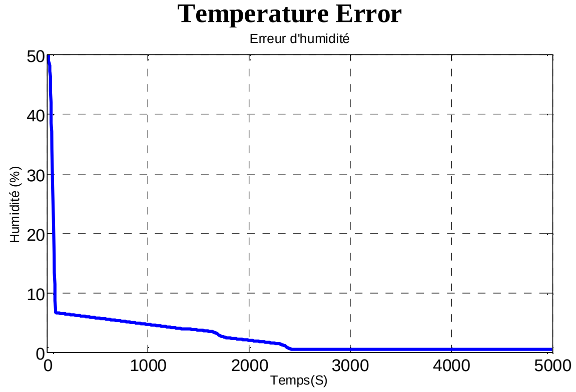
International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 24 (2015) pp 43983-43992



External Humidity versus time



Temperature Error



Error Humidity

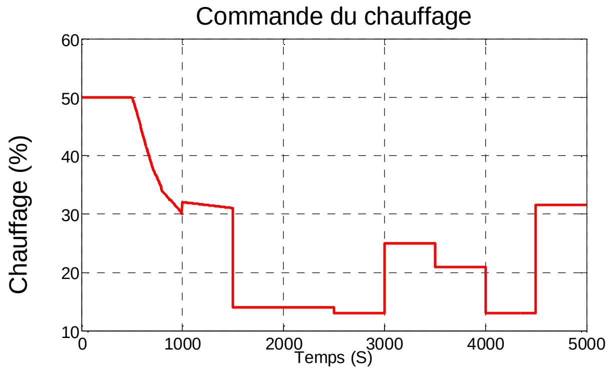
Fig. 9: Inputs of the Fuzzy Controllers

The two upper graphs represent external disturbances of temperature and humidity respectively, and those below the error between the reference and the measured value, for the temperature (T_{ref} - T_i) and for humidity (H_{ref} - H_i).

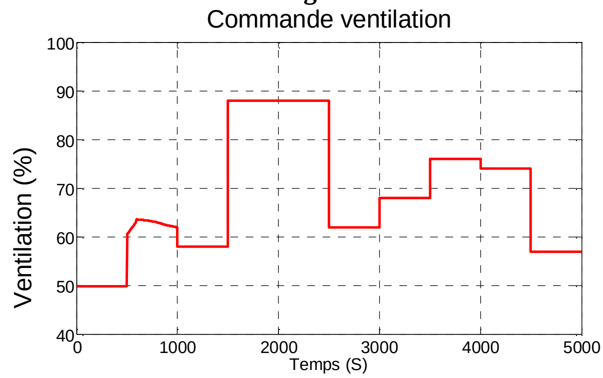
So for example after 1000 s, for external temperature and humidity of 19.2 ° C and 77% the errors by providing references to 25 ° C and 60% are 2.4 ° C for temperature and 5% for humidity.

In our simulation, we chose a step of 500 s (≈ 9 minutes), because changes in temperature Ti and humidity Hi are quite slow in the reality.

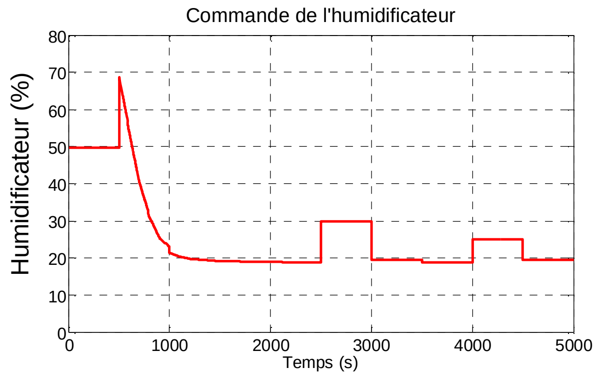
Figure 10 shows the three outputs of fuzzy controllers, heating, ventilation and humidifier.



Heating Control



Ventilation Control



Humidifier Control

Fig. 10: Outputs of Controllers

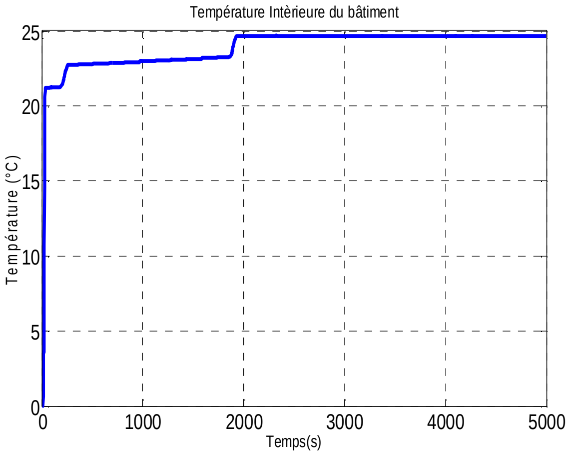
The variations in the curves of these controls show that counteract the effect of disturbances introduced through the external temperature and external humidity.

The figure below shows the curves of the temperature and humidity inside the building.

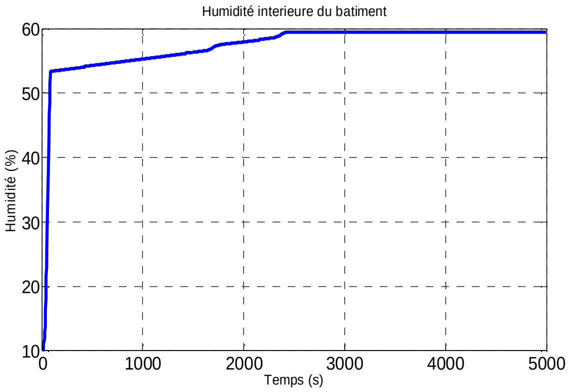
From the results of Figure 11, we note that, without the effect of the regulator, the answer would not only slow, but also too large, which would have a detrimental effect on the chickens (health and nutrition), hence the egg weight and in particular on the performance of laying in general.

Regarding humidity, the effect of our controller fast enough and properly responds to the setpoint.

Finally we have deduced that this controller improves the system appreciably reducing the number of swishing thus increasing the life span of the equipment and thus reducing the operating time a remarkable energy gain as shown table 2



Internal Temperature Controlled



Internal Humidity Controlled

Fig. 11: Internals temperature and humidity (Controlled)

Table.2. Comparison of fuzzy control and classical

	T	DC	NS	E
fuzzy control	18.82	157	26	18316.6
Conventional control relays	19.01	183	38	21350

T: Average Temperature in Celsius
DC: Duration of the command in minutes
NS: Number of switching
E: Energy consumption in wh

B. Comparative study

A comparison study was made on the conventional heating real circuit oravio and simulation, or it has been found that the temperature values are kept almost in both types of actuation. However, the fuzzy control is more advantageous in the duration of the command and the number of switching operations; the recorded energy gain is 3033,4 wh on a period of operation of 500min (8:20), which represents 14.2% of the energy consumed as shows in fig.12.
This result can be generalized to other systems such as ventilation and the humidifier because it is a time gain control. This will give the same impact on investment Photovoltaic because instead of providing the installation of a power 79.3KW for each center Oravio, only install 68KW.

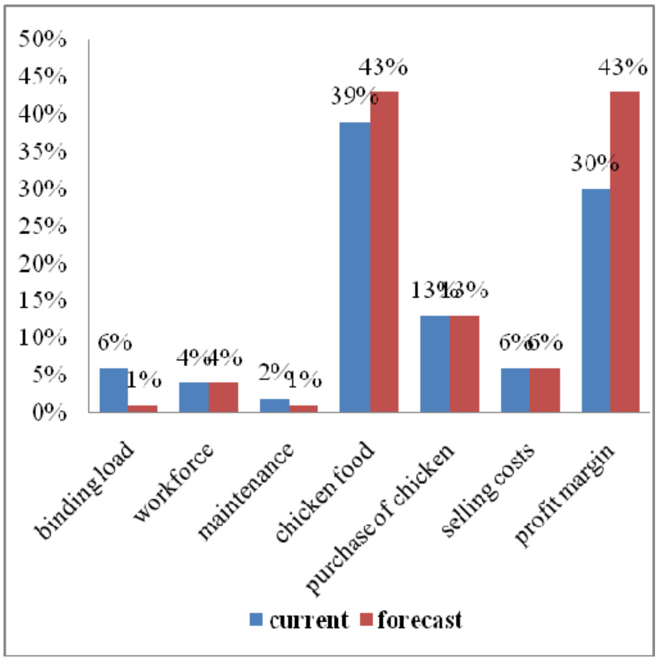


Fig.12. Economic Analysis of egg production

Impact on the performance of Oravio

In addition to energy independence that will have the breeders and the quality of service (lack of central power disturbance) by designing their own GPV.
Climate regulation has an impact even on the Oravio economic record; it will generate an additional profit margin of 13.72% on the price of the egg which will be devoted to early amortization of the investment cost of our project, fig.12.

CONCLUSION

Solar energy is a promising technology to meet the ever growing global demand for electrical energy. It is an abundant energy source, renewable, and environmentally friendly.
The design of the PV plant required an optimal design to meet the energy needs of the livestock company with fewer losses. Several variants calculations were checked by software to choose a feasible configuration, with an acceptable and beneficial plant cost.
This design allows us to contribute to the national network of relief, to ensure constant power availability and quality service to farmers
To improve the investment cost of such a project, we chose a type of fuzzy control algorithm because it is the most suitable for this type of application, for which there does not seem useful to know the exact model of the systems that compose such as PPM and climate barn, because of their complexity, although for simulation needs we had to use a mathematical model.
Given the results obtained, both for the photovoltaic generator in the pursuit of maximum power point, and for regulating the charging and discharging of the battery or to regulate the building climate variables, made controllers present

satisfactory results both on the investment cost plan or even the profitability plan.

Finally, the chicken breeding companies are to a promoter and sustainable project with a very affordable investment cost, which can be amortized as soon as possible with the additional margin induced by intelligent controllers.

In conclusion we also thank the national company of electricity and gas, chicken breeding company laying Tiaret (ORAVIO) biologists and researchers for their valuable contribution

REFERENCES

[1] Bertrand Gaillot, "Cahier technique de la bergerie nationale", Chantal Creusot, Bergerie Nationale de France, Décembre 2011

[2] Omar Chibane, "Techniques de conduite des élevages de poules pondeuses d'œufs de consommation", journal d'aviculture marocaine, Décembre 2012.

[3] Aurore Genieys Aussel, "créer un atelier de volaille en bio", édition Civam Bio Gard 2003.

[4] Institut Technique de l'Aviculture, "Guide d'élevage aviculture fermière", édition ITAVI 1er Trimestre 2009.

[5] Pascal Margol, "Cahier technique produire des œufs biologique", édition –TechnITAB-, juin2010.

[6] ANSEJ Rapport, "Aviculture – Elevage de poules pondeuses", édition 2010.

[7] Yuen-Haw Chang and Chia-Yu Chang, "A Maximum Power Point Tracking of PV System by Scaling Fuzzy Control", revue IMECS, vol II 2010, Hong Kong.

[8] M.Hatti, IEEE Member, " Contrôleur Flou pour la Poursuite du Point de Puissance Maximum d'un Système Photovoltaïque", JCGE 08 Lyon France, Dec2008.

[9] Pongsakor Takun, Somyot Kaitwanidvilai and Chaiyan Jettanasen, "Maximum Power Point Tracking using Fuzzy Logic Control for Photovoltaic Systems", revue IMECS, vol II 2011, Hong-Kong.

[10] N. Ould Cherchali, A. Morsli, M. S. Boucherit et L.Barazane, "Application de la Logique Floue pour la Poursuite du Point de Puissance Maximale d'un Système Photovoltaïque", revue énergies renouvelables, vol10, 2008.

[11] Messaouda Azzouzi, "Comparaison between MPPT P&O and MPPT Fuzzy Controls in Optimizing the Photovoltaic Generator", revue IJACSA, vol 3 N°:12, 2012.

[12] A. Daoud et A. Midoun, "Commande Floue de la Charge d'une Batterie dans une Installation Photovoltaïque", revue énergie REM :ICPWE, 2003 (p67-72).

[13] L. Messikh, S. Chikhi, F. Chikhi, "Mise au point d'un régulateur de charge / décharge de batterie avec seuils adaptatifs de tension pour les applications photovoltaïques ", revue énergie renouvelables vol 11 N° :2, 2008 (p281-290).

[14] Jean-Marc Cottier, André Mermoud, " Centrales photovoltaïques. Guide pour le dimensionnement et la réalisation de projets à l'usage des bureaux d'ingénieurs", édition PACER 1996

[15] www.sunlab.com.br, Copywright Labramo Centronics I.C.L td Dernière mise à jour :07/2011.

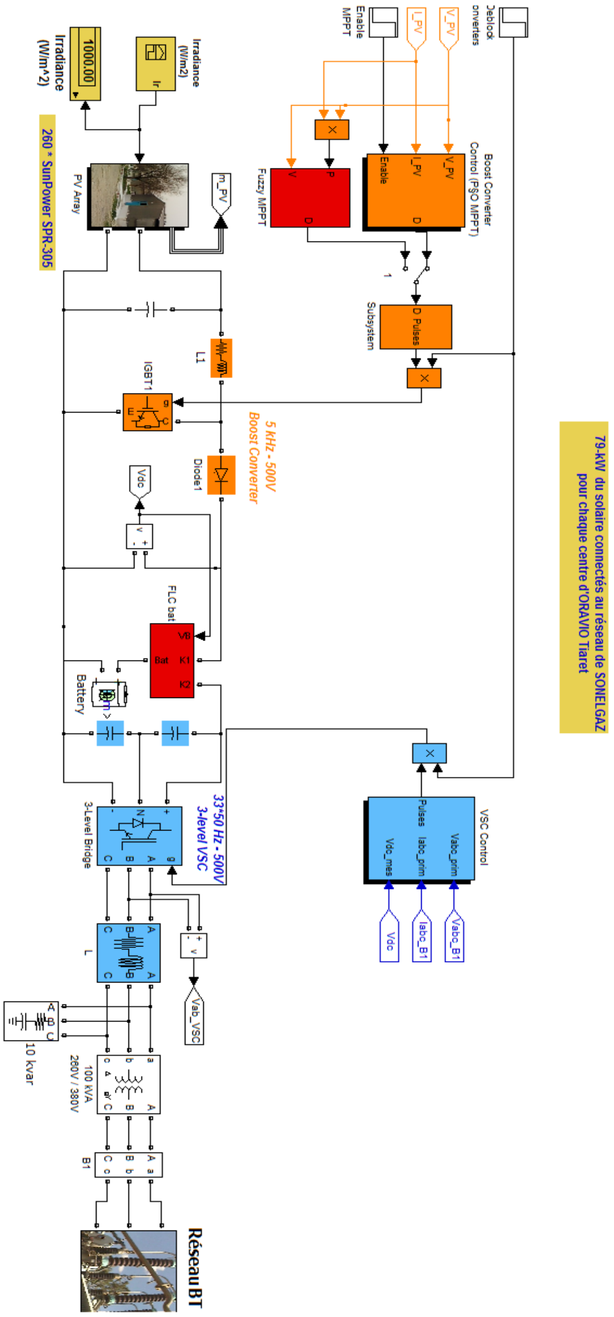
[16] www.photovoltaique.info. Dernière mise à jour : 3 octobre 2012.

[17] Saurav Satpathy « Photovoltaic power control using mppt and boost converter ». The thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering, Department of Electrical Engineering, National Institute of Technology; Rourkela May 2012.

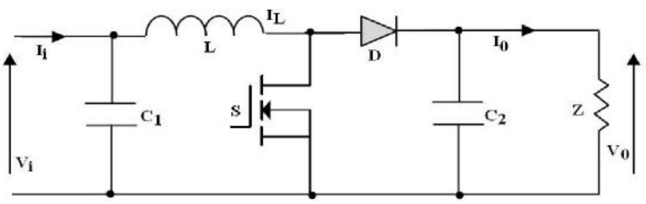
[18] Christophe Batard, Frédéric Poitiers, Christophe Millet and Nicolas Ginot. « Simulation of Power Converters Using Matlab-Simulink », MATLAB - A Fundamental Tool for Scientific Computing and Engineering Applications - Volume 1, 2012.

Sonelgaz : Algerian National Company of Electricity and Gas
ORAVIO: Poultry Regional Office West.

Annex



Annex.1. The photovoltaic generator for the center of Oravio Tiaret Matlab-simulink



Annex.2. Equivalent Electric Circuit of the Boost Converter