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Control and Management of Residencial Load in Micro-Grid

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***Abstract*— The importance of energy from renewable resources, such as wind and solar, is increasing and their penetration rate in power increases each year due to several factors. Firstly, the perpetual rise in demand, particularly because of population growth and economic development. Second, pledges made by many Governments to increase their reliance on renewable sources of energy, with a view to reducing the devastating consequences of climate change on the environment. The multiplication of decentralized production connected to the low-voltage power grid causes the appearance of a bidirectional energy flow. This is at the origin of many electrical phenomena that are increasingly difficult to manage it by distribution system operators. An innovative solution consists in controlling the integration of renewable energies and managed the flow of the powers for a different source. This work covers integration of renewable energy into the public grid for hybrid system. Or more precisely, a microgrid that contains two renewable energy sources (PV + wind), battery and public network all the system is connected in a residential charge. Furthermore, the control of all devices for this integration, management of load from renewable energy and public grid.**

Keywords—Renewable energy; Wind; Solar; Management; Microgrid

I. Introduction

Today, in many countries, there is a sharp increase in decentralized generation sources (solar photovoltaic, wind, hydroelectric, heat-power coupling, etc.) with the addition of the storage system and the diesel generator that are connected to the utility grid. The multiple combination of these sources that are called hybrid power systems.

Although positive, the multiplication of these sources of energy connected to the low voltage (LW) electrical network also has limits. In fact, the decentralized injection of electricity into the grid (by fossil and /or renewable sources) is a factor of instability.

This is due to the presence of a final consumer who, having become both a producer and a user of electricity, causes the appearance of a bidirectional energy flow using an infrastructure that was not designed, at the same time, originally, to welcome him.

Paradoxically, a good coordination of these different sources of injection would better manage power flows and have better oversight of the quality of electricity [1]. The general trend is therefore to move towards the use of smart grid or namely micro-grid. Research in the field of microgrid system has been reviewed in the preview studies using the computer tool and control strategy [2].

This work aims to design a simple micro-grid that includes two renewable energy sources (PV + Wind) and a storage battery, this system is connected in a public grid and do not forget the control system. The study is done in MATLAB interface.

To carry out this work, this paper is divided into six sections. the first section is an introduction. Section 2 presents a generality on micro-grids. The operation of the photovoltaic system and the wind turbine was devoted in sections 3 and 4 successively. The model and the simulation results are presented in section 5. Finally, we conclude this work with a conclusion presented in section 6.

II. MICRO-GRID

With the progress of human society, electric power has been the symbol of modern civilization. Power supply reliability and power quality have become more and more important. Facing pressures from traditional resource depletion and environmental pollution, power generation methods based on fossil fuel and the centralized power supply mode have been difficult to meet the requirements of economic and social development. So, to facilitate access to energy, local-scale power generating and consumption systems called microgrids are gradually being introduced [3].

Microgrid idea is generally developed in countries such as the United States, Canada, Japan and the United Kingdom. It has been investigated and implemented [4]. micro-grid is defined as a system that consisting of renewable sources integrate in the electrical grid, small in size, it comprises low voltage (LV) system with distributed energy resources (DERs) together with storage devices and flexible loads, which can be operated in either on-grid (grid connected) or off-grid (islanded) mode of operation [5][6].

Design of a microgrid can be differentiated according to the applications and expectations. Some microgrids are developed to achieve high end use reliability and stability. Reliability is a common property for a microgrid. Microgrids are able to use more reliable and controllable energy sources like diesel sets, natural energy sources etc. to ensure reliability and stability of the system. Most of these types are implemented as a backup system for large industries and

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military stations located in remote areas. Some others will integrate more renewable and waste energy resources. Overcoming limitations introduced by these kinds of resources is a challenging task. It is seen that there is no clear common architecture for micrograds. So, design, implementation and operation of a microgrid are differentiated according to the purpose [7].

A microgrid is typically made up of:

- Renewable energy sources (solar, wind or biomass).
- Fossil fuel energy sources to ensure grid stability.
- Energy storage solutions (batteries, hydrogen storage, mechanical storage, etc.).
- A low-voltage supply grid regulated by a smart control system.

“Fig. 1,” represents the general design of a micro-grid system.

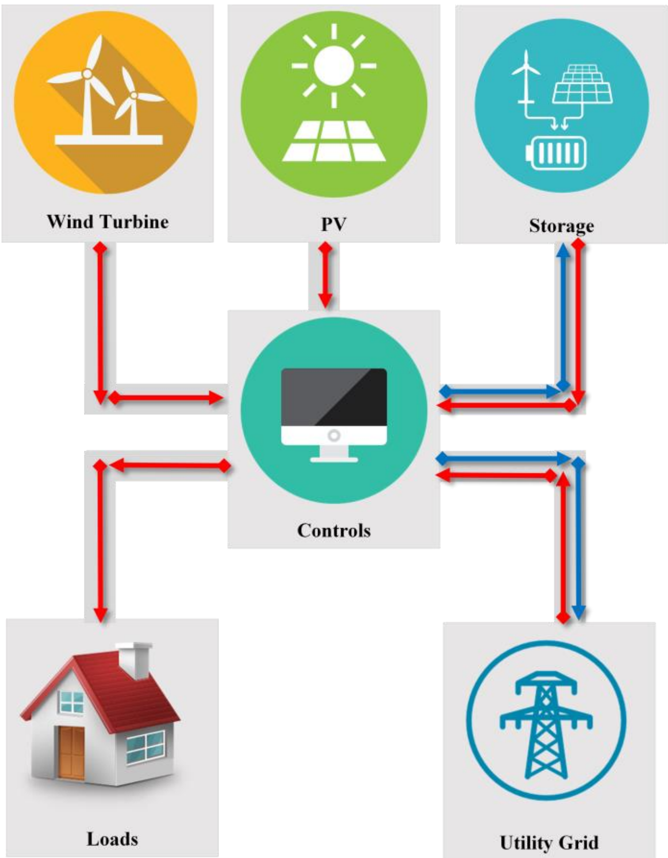

Fig. 1. General structure of a micro-grid.

III. PHOTOVOLTAIC SYSTEM

Photovoltaic solar energy comes from the conversion of sunlight into electricity due to the photovoltaic effect [8][9]. When the photons of sunlight come into contact with the semiconductor materials, they are given the necessary energy for the electron to move from one band to another, this movement produces an electric current [10]. This continuous micropower current calculated in watt peak (Wc) can be converted into alternating current due to an inverter.

The equivalent circuit of a photovoltaic panel is shown in Fig. 2. It includes a current source, a diode, a series resistor and a shunt resistor [11].

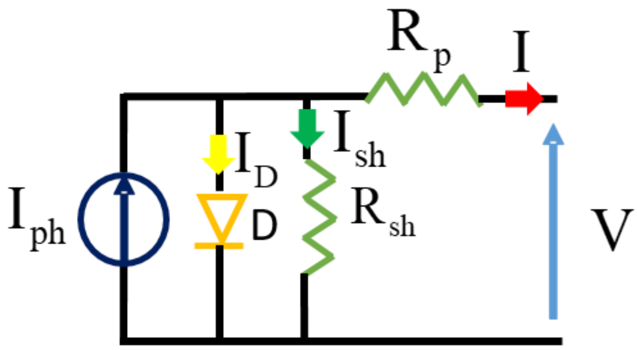

Fig. 2. Electrical model of a PV panel.

Based on the circuit Above and using Kirchhoff law, the current generated by the solar panel can be determined [12], as in (1).

$$I=I_{ph}-I_0\left(\exp\frac{q(V+R_S I)}{aKTN_S}-1\right)-\frac{(V+R_S I)}{R_P} \quad (1)$$

Where

$$I_{ph}=\left(I_{SC}+K_i\left(T-298.15\right)\right)\cdot\frac{G}{1000} \quad (2)$$

$$I_0=\frac{I_{SC}+K_i\left(T-298.15\right)}{\exp\left(\frac{q(V_{oc}+K_V(T-298.15))}{aKTN_S}\right)-1} \quad (3)$$

Where I_{pv} and I_0 are the photovoltaic and saturation currents of the array; I_m and V_m represent the voltage and the current at the terminals of the module; R_s and R_p are series and shunt resistance; T mean the ambient temperature in Kelvin; G [W/m²] is the irradiation on the device surface; q represents the charge of the electron; a is the factor of ideality.

IV. WIND POWER SYSTEM

wind energy is a renewable source energy that transforms the wind's kinetic energy into electrical energy. “Fig. 3,” shows the operation of this energy.

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Vol.7 pp.59-63

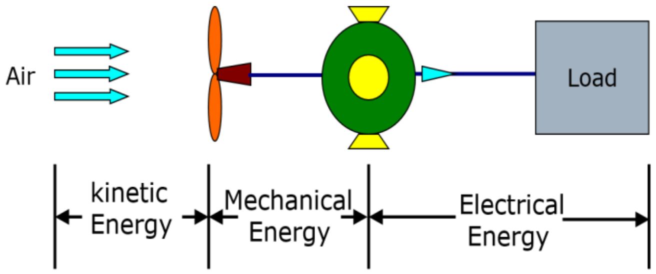

Fig. 3. The operation principle of wind energy.

The model is based on the steady-state power characteristics of the turbine. The output power of the turbine is given by the following (4) [13].

$$P_m = \frac{1}{2} C_P \times S \times \rho \times V^3 \quad (4)$$

Where

P_m: Mechanical output power of the turbine (W).

C_p: Performance coefficient of the turbine.

ρ: Air density (kg/m³).

S: The Total Blade Area swept by the rotor blades (m²).

V: The wind velocity (m/s).

V. MODEL PROPOSED

The proposed model of this work using MATLAB is illustrated in Fig. 4. The micro-grid contains a photovoltaic system, wind, public grid and a battery that are connected to a load.

The photovoltaic system is characterized by a power of 4.5Kw and a voltage of 290V for a temperature of 25°C and an irradiance of 1000 W/m². The Maximum Power Point Tracking (MPPT) control takes maximum power from the solar panel using a unidirectional DC/DC converter.

The wind turbine in this model generates a power of 3 Kw and a voltage of 440V, this source is connected in an AC / DC rectifier.

A controller consisting of a power conditioning system and a battery control system is also connected directly to the system.

The power grid is connected to the system by a pole-mounted distribution transformer. It can absorb or demand energy from the system.

the previous three elements (PV + Wind + Battery) that are putting in cascade, they are connect to a bidirectional DC/AC inverter which connected in series with a public grid.

Three loads of 1.5 kW can be connected to the system. They consume a total of 6 kW of electrical power when All of them are connected.

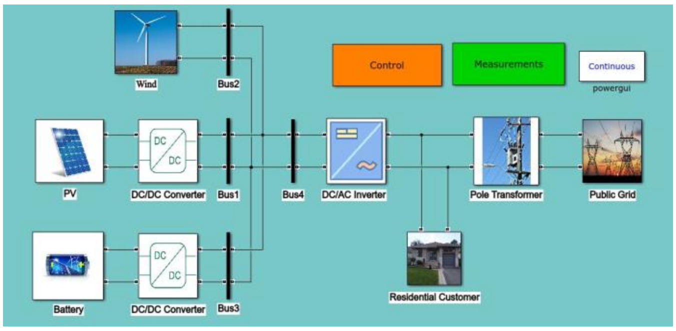

Fig. 4. Proposed micro-grid model.

VI. RESULTS AND DISCUSSION

A. *RESULTS*

After the execution of the proposed model shown in Fig. 4. We obtained the following results:

"Fig. 5," shows the operating time of each load, such that load 1 operates between {0.25-0.75 s and 1.25-1.75 s}, load 2 operates between {0.5-0.75 s and 1.5-1.75 s} and load 3 works between 0.75-1.25 s.

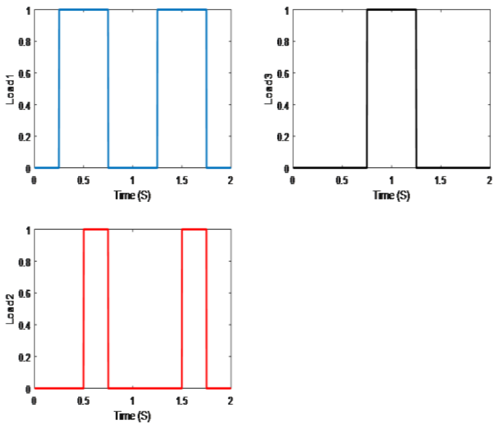

Fig. 5. the operation time for the three loads..

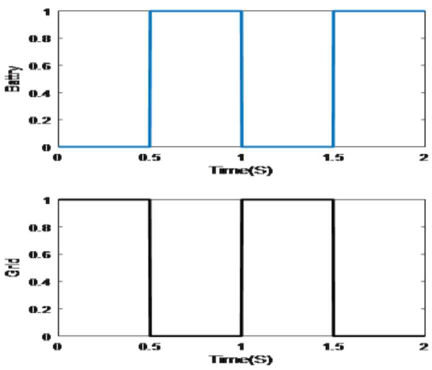

Fig. 6. The operation time for the battery (blue) and the grid (dark).

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Vol.7 pp.59-63

“Fig. 5,” shows the operating time of the grid and battery. we managed the time so that if the grid works, the battery is disconnected and vice versa. This management makes it possible to maintain the continuity of service.

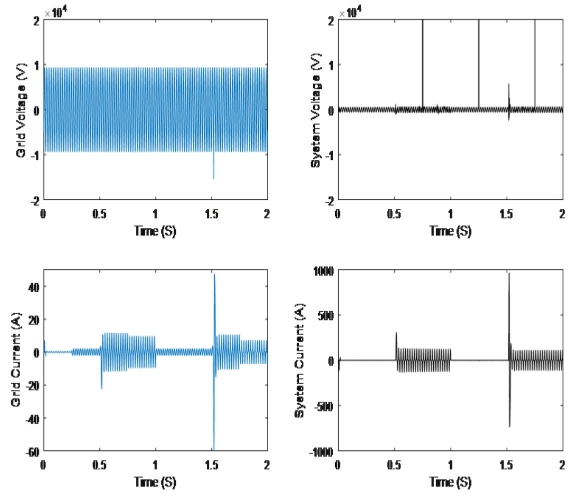

Fig. 7. The voltage and current profile for: the grid (blue), the hybrid system (dark).

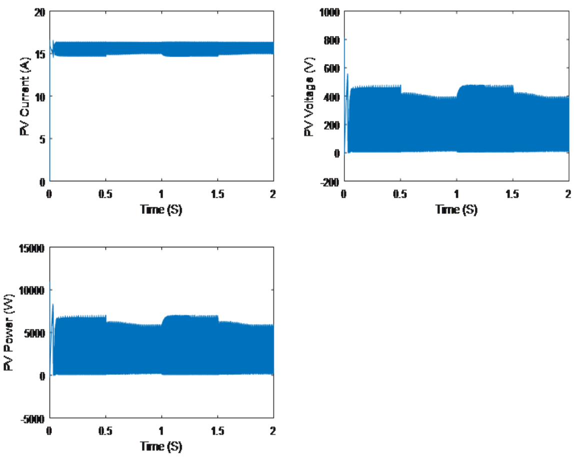

Fig. 8. The current, voltage and power profile of the PV.

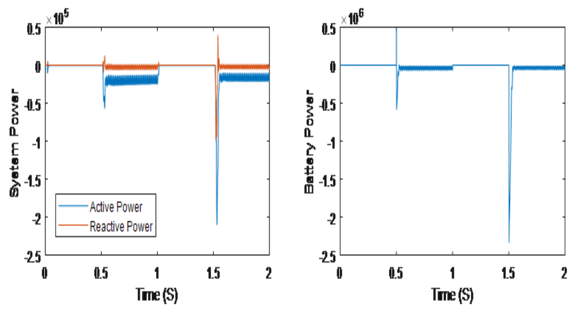

Fig. 9. The power profile of the battery (right) and the hybrid system (left).

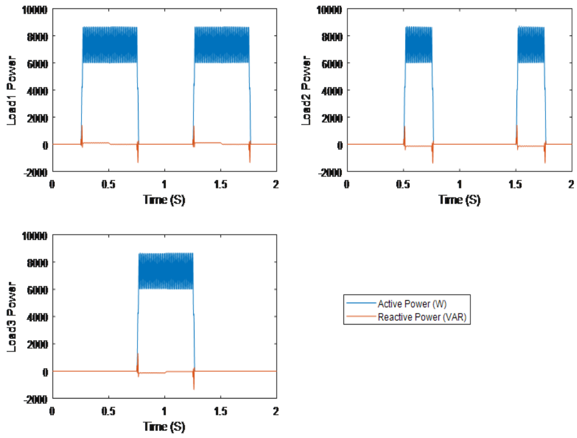

Fig. 10. The power profile of the three loads.

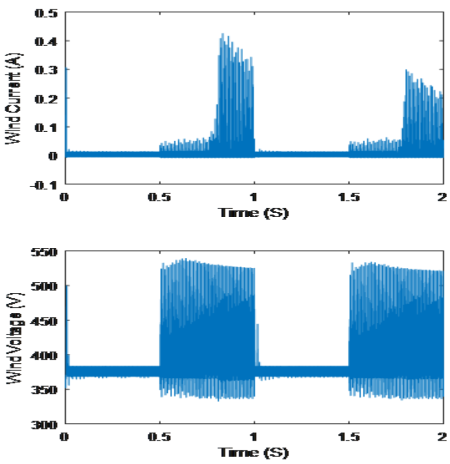

Fig. 11. The current and voltage profile of the wind.

B. *DISCUSSION*

1) Grid connected

- The battery is not connected to the system and the charges are not activated.
- The power generated by the hybrid system is sent to the public grid.
- The power generated by the hybrid system is kept approximately constant at the nominal power due to the integration of the control system.

2) Battery connected

- The grid not yet connected.
- The power generated by the system is negative because all three loads are connected. The system requires an additional energy from the grid.

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- The power generated by the system hybrid rest constant.

Load 1 et 2 then disconnected, load 3 is disconnected at time (t=1.25 s). Then the battery is connected to the system. Therefore, we can disconnect the public grid management system because the hybrid system (PV + Wind + Battery) is sufficient to provide the total load.

VII. CONCLUSION

In this article we started by giving a generality on the micro-grids system. Then we present the two renewable energy sources (PV + Wind) that we used in this work.

this system consists of a photovoltaic source, a small wind source, a storage unit that is the fuel cell and a load of 6kW, the whole is connected to a DC bus.

We realized this global system in MATLAB Simulink, with the setting of the initial variables of each component. In addition, we have installed a process to control all system variables, such as DC bus voltage control, MPPT control, control of the DC / AC converter for the synchronization of the AC output with the public grid. As we have installed a power

management system et de control from all sources that is in the charge, battery and public grid.

Finally, the simulation is launched in a duration of 2 s, the results obtained are satisfactory fact that, the following functions are provided:

- The control of system components and variables facilitates the integration of renewable energies in public grid and guarantees operation even in adverse cases.
- The installation of a power management system plays a very important role not only to promote the use of renewable energies but also the reduction of the use of the public network (consumer become both a producer and a user of electricity).

REFERENCES

[1] J. Jaton, G. Besson, M. Carpita, and D. Ducommun, “Gestion intelligente et autonome du réseau électrique basse tension,” Electrosuisse, Technopark, Zürich, 17.Oktober 2013.

[2] M. H. Nehrir, C. Wang, K. Strunz, H. Aki, R. Ramakumar, J. Bing, Z. Miao, Z. Salameh, “A Review of Hybrid Renewable/ Alternative Energy Systems for Electric Power Generation: Configuration, Control, and Applications”. IEEE Transactions on Sustainable Energy, Vol. 2, No. 4, October 2011, pp. 392-403.

[3] Y. Xu, Z. Shi, J. Wang and P. Hou, "Discussion on the Factors Affecting the Stability of Microgrid Based on Distributed Power Supply," Energy and Power Engineering, Vol. 5 No. 4B, 2013, pp. 1344-1346.

[4] M. Moradian, F.M. Tabatabaei, and S. Moradian, “Modeling, Control & Fault Management of Microgrids,” Smart Grid and Renewable Energy, Vol. 4, No. 1, 2013, pp. 99-112.

[5] N.A LUU, “Control and management strategies for a microgrid,” Saint-Martin-d'Hères, Grenoble University, December,18, 2014.

[6] A. Vinayagam, K.S.V. Swarna, S.Y. Khoo, A.T. Oo, and A. Stojcevski, “PV Based Microgrid with Grid-Support Grid-Forming Inverter Control-(Simulation and Analysis),” Smart Grid and Renewable Energy, 8, 1-30, 2017.

[7] M. Ariyasinghe and K. Hemapala, "Microgrid Test-Beds and Its Control Strategies," Smart Grid and Renewable Energy, Vol. 4 No. 1, 2013, pp. 11-17.

[8] M. Venkateshkumar, R. Indumathi, and P. Poornima, “Photovoltaic cell power generation for stand-alone applications,” IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012), pp. 57-62.

[9] R. Indumathi, M. Venkateshkumar, and R. Raghavan, “Integration of D-Statcom Based Photovoltaic Cell Power in Low Voltage Power Distribution Grid,” IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012), pp. 460-465.

[10] M. Venkateshkumar, and R. Raghavan, “Hybrid Photovoltaic and Wind Power System with Battery Management System using Fuzzy Logic Controller,” Vol. 5, No. 2, August 2016, pp. 72-78.

[11] M. G. Villalva, J. R. Gazoli, and E.R. Filho, “Modeling and circuit-based simulation of photovoltaic arrays”, Power Electronics Conference, COBEP '09. Brazilian, 2009, pp. 1244-1254.

[12] H. Bellia, R. Youcef, and M. Fatima, “A detailed modeling of photovoltaic module using MATLAB,” NRIAG Journal of Astronomy and Geophysics, Vol. 3, No. 1, June 2014, pp. 53-61.

[13] K. K. M. S. Kariyawasam, K. K. N. P. Karunarathna, R. M. A. Karunarathne, M. P. D. S. C. Kularathne, and K. T. M. U. Hemapala, “Design and Development of a Wind Turbine Simulator Using a Separately Excited DC Motor,” Smart Grid and Renewable Energy, Vol. 4 No. 3, 2013, pp. 259-265.

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