Modeling and Real Time simulation of Microgrids in Algerian Sahara area

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***Abstract*— Microgrids are, as their name implies, real-time networks operating between producers, distribution companies and consumers.**

The climate of the Sahara is hot, sunny and arid. This part of Algeria is a hot desert, located on both sides of a tropic. Daytime temperatures are very high, can exceed 50°C, and the thermal amplitude between day and night is often higher than 35^0 C or 40^0C. Addition to this, there are many microclimates which are characterized by very high wind speed. It means that both of wind and photovoltaic energies are widely suitable in this area.

Aim of this work is to model and simulate operation of microgrids in these areas, including micro power plants, photovoltaic panels, wind farms, diesel power and storage energy, and finally we will apply the model in Real time simulation thanks to MEGASIM of the RT-LAB platform.

Results obtained by this tool will allow us to have a very accurate vision of Microgrids operation, in term of power flow or default responses.

Keywords—Sahara area; microgrid; modeling; real time simulation.

I. INTRODUCTION

Electricity market in Algeria is developing continuously; Sonelgaz (National Society of electricity and Gas), is the major provider of electricity and gas utility. Power plants generation in the country is open cycle gas turbines, combined cycle gas Turbines, conventional steam turbines and more recently renewable energy sources. Recently the covering capacity for electricity installations network is 98% in which more than 80% is being in the north [1].

Most of electrical installations in the south are powered by diesel or gas. Because of the faults of these production groups, it is necessary to instal other sources of production, such as renewable energy, all realizing the microgrids.

Several scenarios will be considered for the realization of the microgrid in the Algerian Sahara area, according to region and climate:

- PV solar with wind power with diesel power with storage energy.
- PV solar with wind power and diesel power.
- PV solar diesel power with storage energy.
- PV solar with wind power with diesel power.

As we notice in figure 1, north network is much meshed and strongly interconnected. On the contrary, south is poorly connected because of its wide surface, and a lot of desert uninhabited areas.

For these reasons, renewable energies, and micro power plants are a suitable solution to provide electrical power to this part of the country.

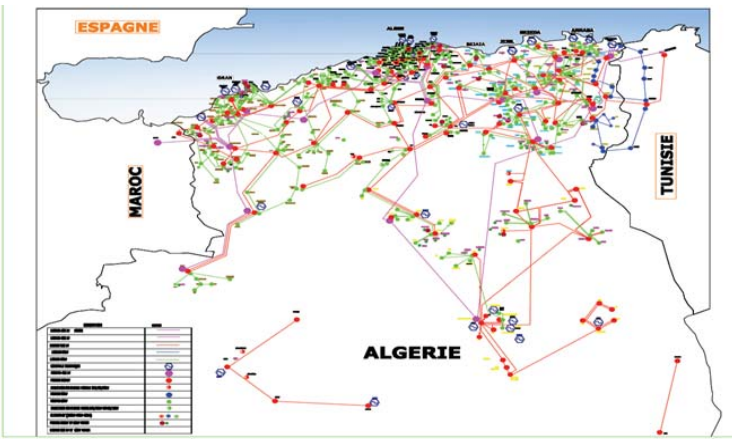

Fig.1. Algerian electricity grid [2]

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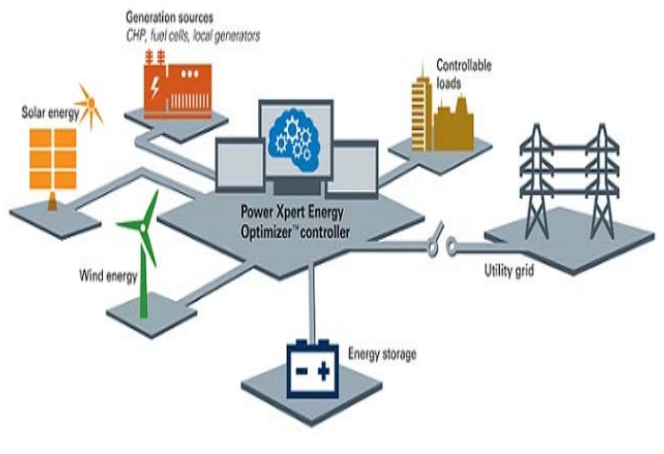

Fig. 2. Microgrid Scenario

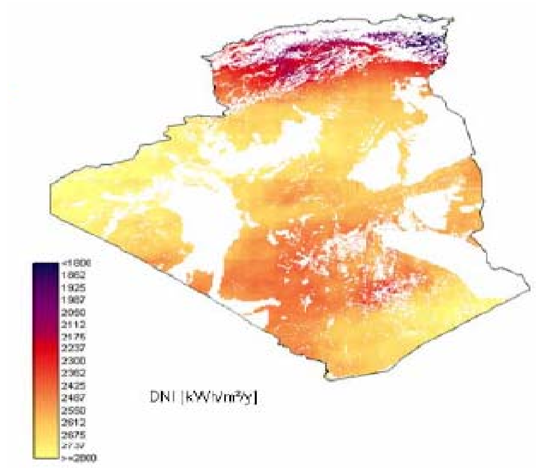

Fig 4: Solar potential in Algeria

II. RENEWABLE ENERGY IN ALGERIA.

National priority for Algeria is to diversify sources of energies by inserting renewable power plants. Algeria has a big potential in solar energy, and have ambition to become a leadership in MENA area, and a serious partner in the world. Alternative energies, like solar and wind are a serious and efficient alternative to ensure energy security supply, reliability, increasing efficiency in energy conversion, transmission and distribution. In particular, Sahara Algerian desert have a phenomenal potential [9].

In Sahara, since the seventies, national program strongly supported utilization of renewable energies, mainly solar first, but now wind generation is also enhanced. (Fig.3)

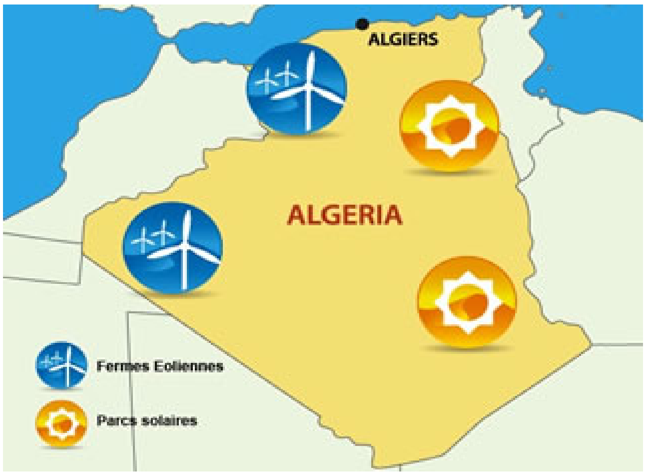

Fig.3. Algerian renewable energies distribution

Economically, a conventional power supply by extension of the networks is not adapted to the distant centers. This is true for the areas of the Sahara with its surface about 2millions km^2, and only an autonomous means of feeding is to be envisaged. For this reason, Microgrids is the suitable solution.

The sunshine of these regions has made it possible to resort to electrification by solar energy and wind energy [3].

Photovoltaic energy offers an ideal solution thanks to its phenomenal potential. Photovoltaïque technology is enough well proven that it is clean, durable, efficient and highly scalable. This technology is easy to integrate in any area, in both developed and developing countries. This is why, the program of renewable energies in Algeria is based on photovoltaic first, followed by wind energy [3],[9].

III. REAL TIME SIMULATION

In response to the increasing demands of electrical systems for performance, reliability and cost, the command, control and protection equipments has become increasingly sophisticated.

It is essential to validate this equipment before they are installed on the real power system. To accelerate the development and validation cycle of these equipments, to reduce costs and risks, the current trend is to test these equipments with a real-time digital simulator. The objective of the real - time simulator is to test the different electrical equipments in the most natural possible conditions: as if they were connected to the real physical systems associated with them. Therefore, the real-time simulator must reproduce as closely as possible the dynamic behavior of the electrical system under control [4].The real-time simulation of the electrical system to be controlled passes first through:

1) - A modeling phase that consists in the putting of equation of the system.

2) -Then a phase of conception of an algorithmic specification (choice of sampling period, discretization and quantification)

3) - And finally, a phase of real - time implantation [5].

3.1 Hardware Architecture

The hardware architecture installed within our laboratory SCAMRE, it is composed of two connected simulators, the Wanda 4u and the OP 5600 (Fig. 5). The target has two CPU processers including 2 cores enabled and 16 I/O, for Wanda and two CPU processers including 2 cores enabled and 16 I/O, for OP5600 (Fig. 6) **.**

Main task of the target is the execution of different models. Development, editing, verification, and compilation of models are realized on the host computer. Its second assignment is that it works as a console or command station in charge of control and observation during simulation. Ethernet is used to communicate between hosts and targets. The host computer is a general PC [6].

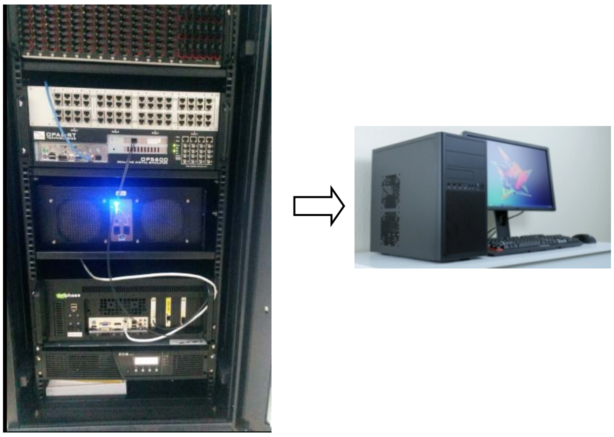

Fig. 5. RT-LAB Simulator Architecture

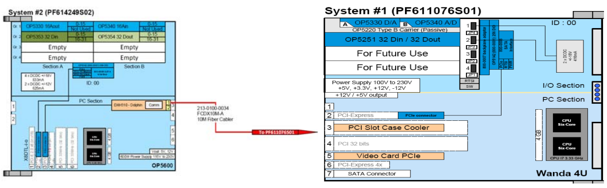

Fig .6. System Hardware Overview for OP 5600 and Wanda 4u

3.2 Software architecture

Software architecture on the host is shown in Figure 7. All studied models must be developed under the Matlab/Simulink environment. RT-LAB is a real-time GUI platform, and it is dedicated to achieve the real-time simulation of the Simulink models. RT-LAB builds parallel tasks from the original Simulink models and run them on each core of the multi-core CPU computer [2].

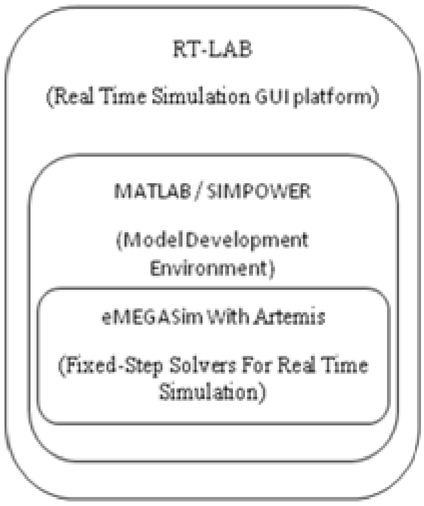

Fig.7. Software architecture

In the platform of RT-LAB simulation, a solver named Artemis (is a fixed time-step size solvers) which is designed specifically for power system, can improve the simulation speed greatly. Multi-processor operating mode allows it to achieve real-time simulations on RT-LAB platform. Purpose is to separate a complex system to some simple subsystems and do parallel operations in multiprocessor. RT-LAB is able to connect physical devices to the simulation system to make the simulation closer to the reality and get more realistic results**.**

IV. MODELING OF A MICROGRID IN ADRAR AREA

In this chapter, we are interested to the microgrid of the Adrar area, where a wind farm, a photovoltaic farm and a turbine gaz generator are installed.

V.1. General architecture

Microgrids conception will start with Kabertene wind farm (70 km north of Adrar), which have a capacity of 10 megawatts (MW). It consists of 12 wind turbines with a unit capacity of 0.85MW each and the energy produced will be evacuated to the 220 / 30KV substation which is in the locality itself [9].

A simulation model has been built represented in Fig.8

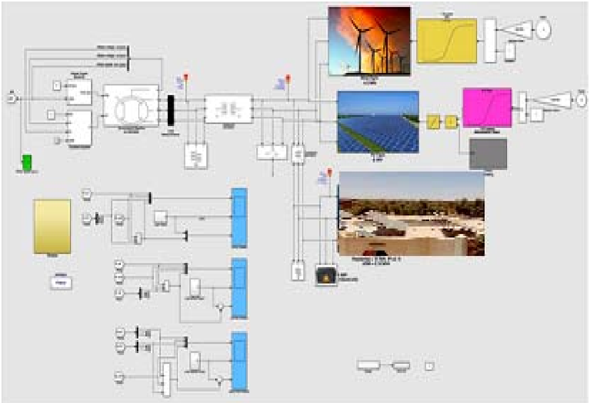

Fig. 8.Microgrids architecture

TABLE1. Characteristics of wind farm:

Society	GAMESA
Model	G52/850
Wind turbine number	12
Nominal power/unt	850,0 kW
energy per year	3,42 GWh (Vmoy: 8,5 m/s,
Secondary Generator	0,0 kW
rotor Diameter	52,0 m
Column	Tubular shape
Generator type	Variable
Rms in nominal power	26,2 t/mn
height of the column	55,0; 44,0; 49,0; 65,0 m

Adrar area seems to be the best location for installation of wind farms. As we see in Fig.9 below, wind speed value is proportional to generate wind power [9].
Several studies assumed that mean wind speed is around 14m/s, which is an interesting value [1].

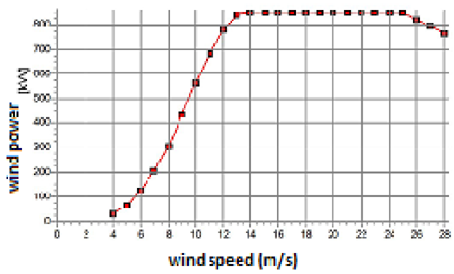

Fig 9. Wind power curve

Second element is the Zaouiet Kounta power plant (80 km south of Adrar). With a production capacity of 148 megawatts, this plant allows the wilaya to ensure self-sufficiency over 10 years, thanks to its production provided from its 8 gas turbines.

A production that contributes to supply the wilaya via two power lines, one to the South to In-Salah (Tamanrasset) and the other north to Timimoune (Adrar).
Third power source is solar power plant of Kabertène (3MW)

V.2. Microgrid operation

As we cited bellow, Adrar area is mainly supplied by gas turbines. But, there is around this locality a lot of isolate populations which are powered by both wind and/or solar energy.

Renewable energy sources connected to the micro-grid are connected to the main network by relays. As soon as one of the sources is insufficient to feed the load, the corresponding switch opens, and the other closes.ie

Case 1: If wind speed is sufficient to produce the energy, wind turbines are connected to the load.

Case 2: The speed of the wind and the sun produce sufficient energy at the same time: wind turbine is connected with the load, and the photovoltaic panels charge the storage battery.

Case 3: If wind speed is insufficient, and sun radiation produce sufficient energy so the photovoltaic is connected the load.

Case 4: Both of wind and photovoltaic generation is insufficient, the load is connected to the grid.

Main objectives of Microgrids conception are to investigate full-scale development, field demonstration, and highlighting performance evaluation of:

- Frequency and voltage control different methods and technologies, under various Microgrids operation modes.
- Switching between grid-connected and islanded modes.
- High DER penetration and its impact on the host grid and interaction phenomena between DERs.

We must have in mind that strategies of control, and dynamic behavior of a Microgrid in autonomous mode of operation, might be different than that of a conventional power system [6].

V.3. Modelling and simulation of microgrid

For better visibility of the project, it is mandatory to realise a model of Microgrids and to simulate it in real time with the Opal-RT software [7].

For this reason, the entire entire model has to be rearranged mainly into three subsystems, which are master, slave and console subsystems. (Fig.10)

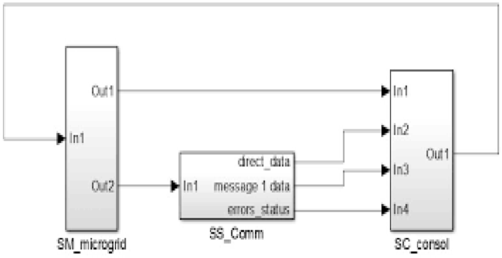

Fig.10. Example of Microgrid model with the real-time software

The Microgrid system is modelled in an environment that integrates Simulink/SimPowerSystems with the eMEGAsim simulation of the RT LAB platform. [2],[6].This platform improve the simulation of increasingly large systems with real-time performance across multiple CPUs.

Next step, we will present different models of Microgrids, defining best adaptive one to real time simulation.
Results with the graphs of the real-time simulation Microgrids models and their interpretations will be later presented in a second part of the article.

V. Conclusion

Application of micro sources can in evident manner, regulate consumption for distribution and transmission facilities.[8]

Particular geography of south Algeria is very suitable to organize diversity of power sources in Microgrids in order to optimize their operation, to make easier their command.

Autonomous Microgrids applications for remote locations are mainly achieved for electrification of electrically nonintegrated areas: like islands, and isolated areas as Algerian Sahara.

Few years ago, some communities in Sahara have been electrically supplied almost exclusively by diesel generators. In addition to reducing fuel costs, the main objective of autonomous Microgrids applications is to investigate and develop field experience with planning and operating autonomous distribution grids [10],[11] .

This article is a first conception of a Microgrid in Sahara area wich includes diesel, wind and solar energy. This will be providing a continuity of service.

RT simulation of this model, will give us real data, and enhance local reliability, by reducing gas emissions, improving power quality by supporting voltage and reducing voltage dips, and giving potentially lower costs of energy supply.

There will be a focus on local supply of electricity to nearby loads. Results of research and field tests are used to identify technology requirements, and to promote electric utility acceptance of the microgrid concept.

References

[1] A.Boudghene S,Z. Khiat,S.Flazi, Y. Kitamura "A review on the renewable energy development in Algeria: Current perspective, energy scenario and sustainability issues", Renewable and Sustainable Energy Reviews 16 (2012) 4445–4460.

[2] M.Khiat; L.Ghomri "" Real time of HVDC and VSC- HVDC models: Application to Algerian- Spanich power system interconnection", ICREPQ'16, Madrid, Spain, 2016Elsevier)

[3] Himri Y, Stambouli ABoudghene, Draoui B. Prospect of wind farm development in Algeria. Desalination (Elsevier) 2009;239:130–8.

[4] H. C. Su, G. W. Chang, H. M. Huang K. K. Jen, G. C. Chun, and G. Z. Wu, "Analysis of Wind Generation System by Real-Time Simulation "National Chung Cheng University Chia-Yi, Taiwan 2012.

[5] User's Guide, "Real-Time Workshop 7 ", by The MathWorks, Inc., 2010.

[6] Pei Zhang, Fangxing Li, Navin Bhatt, "Next generation monitoring, analysis, and control for the future smart control center," IEEE Transactions on Smart Grid, vol. 1, no. 2, September 2010, pp. 186-192.

[7] User's Guide, " SimPowerSystems R2013a ", Hydro-Québec and The MathWorks, Inc., 2013.

[8] Y. Huang, S. Mao, and R. M. Nelms, ``Adaptive electricity scheduling in microgrids," in Proc. IEEE Global Commun. Conf., Apr. 2013, pp. 1⊥9.

[9] http://portail.cder.dz/spip.php?article3811.

[10] N. Hatziargyriou, H. Asano, R. Iravani, and C. Marnay, "Microgrids," *IEEE Power Energy Mag.*, vol. 5, no. 4, pp. 78–94, 2007.

[11] F. Katiraei, R. Iravani, N. Hatziargyriou, and A. Dimeas, "Microgrids management," *IEEE Power Energy Mag.*, vol. 6, no. 3, pp. 54–65, 2008.