BRIEF PRESENTATION ON RENEWABLE ENERGY RESEARCHES IN UNIVERSITY OF CORSICA PASQUALE PAOLI

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ABSTRACT

This research group in Renewable Energy systems belongs to the “Systems for Environment” laboratory (SPE) of the University of Corsica Pasquale Paoli which is a Joint labs partnered with CNRS (National Centre for Scientific Research) under the number UMR 6134. The central theme of our research is the study of the optimal management of energy systems using intermittent renewable energy resources.

A SHORT PRESENTATION OF THE UNIVERSITY AND THE LABORATORY

The young Corsican University was created in 1981 but it succeeded to an ephemeral university instituted in 1765 in Corte during Pascal Paoli’s government. The University of Corsica Pasquale Paoli (UCPP) is a multidisciplinary institution which counts 8 faculties, institutes and schools. It offers 100 diplomas, ranging from two-year undergraduate studies to doctoral studies. Permanently concerned with the occupational integration of our 4600 students, UCPP proposes a highly professionalizing academic offer linked to the main development issues of the territory.

Definitely engaged in an international dynamic, the University of Corsica encourages its students to develop a real culture of mobility. A large and varied cultural and sports offer is also available. UCPP has the necessary human and material means to ensure the students the best possible conditions of education, professional integration and self-fulfilment.

The research is organized in 8 structuring research projects, 6 of which are realized in the SPE laboratory (6 first ones in the list):

1. Fields of Mathematical Frequencies and their Applications
2. Renewable Energy
3. Fires
4. Management and Water Treatment in the Mediterranean
5. Natural Resources
6. IT Simulation and Ubiquitous Systems
7. Sustainable Development and Territory Dynamics
8. Heritage Designation concerning Identity, and Cultures

The research centre opened in Ajaccio (after the second oil crisis in 1979) and was dedicated to the study of solar energy systems and more particularly on a 100 kW-e solar thermal electric power plant using solar tracking concentrators installed on the laboratory site (Fig. 1). In 1983, a 44 kWp photovoltaic pilot plant has been implemented within the solar PV R&D European Economic Community Program (CEE-DG XII) in Paomia Rondulinu (60 km of our laboratory) (Fig. 2) and the researches, if they began with the solar thermal conversion, turned to the photovoltaic conversion and hybrid systems to provide electricity for remote areas. Today, a large renewable energy research domain is treated and will be presented in the next sections.

Figure 1. 100 kWe thermodynamic solar plant

Figure 2. 44 kWp photovoltaic power plant

MAIN ACTIVITIES IN RENEWABLE ENERGY

The main part of the research team in Renewable Energy is working in the Research Centre Georges Peri in Ajaccio which belongs to the SPE laboratory. This team is composed, actually in 2019 by:

- 2 professors;
- 2 assistant-professors with accreditation to supervise research;
- 4 assistant professors;
- 3 researchers under contracts;
- 1 engineer and 1 assistant-engineer;
- 5 doctoral students.

The main domain studied by the Renewable energy team is the energy problematic of islands (700 islands in EU for 16 Mhab and 10 000 islands over the World for about 500 Mhab) in view to improve the integration of intermittent and stochastic renewable energies in insular electrical network (but more generally for non-interconnected electrical networks).

The intermittent and stochastic character of solar and wind energy resources limits the integration rate of such systems in an energy mix. Today, as an example, in an electrical network the maximum part of power produced by solar and wind is around 30% for security of energy supply (at each instant); beyond this threshold, solar and wind energy systems are disconnected to the electrical network.

To solve this problem, three actions must be realized simultaneously:

- The development of energy storage and their hybridization;
- The development of energy management systems based on the forecasting of the production and the consumption;
- The development of smart grids and more generally of smart villages and smart building.

It is into this context that the research and development (R&D) activities are realized. They mainly focuses on “the optimal management and the rational of intermittent renewable energy sources”. More precisely, these researches can be divided in:

- Estimation and forecasting of the intermittence of the solar resource
- Integration of stochastic renewable energy systems in small electrical island networks
- Integration of PV and thermal solar collectors in buildings

Two R&D platform allow to validate the work: MYRTE and PAGLIA ORBA and will be presented in the next section.

THE TWO R&D PLATFORMS

The two R&D platforms in renewable energy located in Vignola, near Ajaccio, at the Georges Peri Scientific Studies Center.in the laboratory are:

- MYRTE, Mission hYdrogène Renouvelable pour l’intégration au réseau Électrique, in english « Mission renewable hydrogen for an integration in an electrical network »;

The Myrte Platform

Sponsored by the CNRS (National Center for Scientific Research), the AREVA Energy storage space and the CEA (Atomic Energy Commission, today Alternative Energy Commission), the University of Corsica’s MYRTE platform research is dedicated to the production and the storage of solar energy. Its objective is to redistribute this energy within the electricity network during periods of strong daily use, and/or to mitigate the extreme power fluctuations inherent in energy that the photovoltaic power plant supplies.

The platform’s goal is to produce and store energy through a Hydrogen chain. This consists of an electrolysis apparatus, which, during hours of weak consumption, produces hydrogen and oxygen from water molecules.

This energy is then distributed via a fuel cell that recombines the hydrogen and the oxygen into water, producing electricity; for example, in the evening during hours of important consumption, while the photovoltaic panels are inactive. This apparatus also produces heat that can be stored for various secondary uses.

Hooked up to the EDF (French Electricity Supplier) network since 2012, the power plant produces the equivalent of the electrical consumption of 200 homes. This research developed a control-command system that optimally runs all the equipment, according to functional algorithms developed by our researchers.

By their size and their assimilation in the electricity network, the MYRTE platform is one of the rare sites in the world, capable of studying the duo renewable energies and storage under real conditions.

The PV plant has a peak power equal to 550 kWp with 28 x 17 kW of inverters. The hydrogen chain is composed by a 46 kW Electrolyser and a 100 kW fuel cell with a H₂ gas storage of 56 m³ at 35 bars for a stored energy equal to 1.75 MWh. A general presentation of the Myrte platform is shown in Figure 3.
Some thermal studies can be also realized in this experiment due to the heat produced by the fuel cell and the electrolyser and which can be upgraded (about 800 kWh per day).

This system coupled with an Energy Management System allows to improve the management and the stability of the electrical system with three main objectives:

- The smoothing of the PV production to make it less intermittent (Fig. 4.a);
- A guaranteed energy production (Fig 4.b);
- The shaving of the peak power in replacement of fuel generators in islands (Fig. 4.c).
The Paglia Orba Platform

This platform is actually partially functioning. The objectives of this platform are:
- to study the coupling between the energy production means using renewable energies (particularly solar intermittent source) and various energy storage means;
- to test the “decentralized energy management” using a smart grid and smart energy management in a medium voltage grid; this smart grid have the ability to manage and to anticipate the consumption of the users;
- to study and to test two working modes:
  - Self-consumption and injection of electrical energy surplus within the EDF network;
  - Energy autonomy: the electrical system isolates itself from the rest of the global network.

This electrical micro grid platform can be considered as a small village or a neighbourhood of a city. It consists in:

- Photovoltaic solar systems with various technologies: Silicium monocrystalline and polycrystalline, hétéro-junction PV module, CdTe, Gallium Arsenide; some of them are installed on the roofs, on fixed and tracking supports; a Concentrated PV system is also working.
- Energy storage means:
  - mechanical: fly wheels, hydro-pumping station
  - Electrochemical: NaNiCl₂ battery, PB batteries, Lithium battery, ZnBr flow redox battery, fuel cell and electrolyzer…
- Several types of electrical loads: building consumption, electrical car station …

All this network is managed smartly. A general view of the system is shown in Figure 5 and the main components are shown in Figure 6.
This system was conceived in such a manner that other systems can be connected; several configurations can be studied. All the coupling between production system and energy storage can be easily tested. Today about 20 equipment are installed (storage, production, load) between 100 W to 50 kW, all connected to the micro-networks.

OTHER RESEARCH TOPICS

To increase the integration of the intermittent and stochastic production in an electrical grid, three topics must be developed in parallel:

1. **To develop energy storage means** in order to absorb the surplus energy and to release it when the consumption requires.
2. **To develop (smart grids)** for the transport and the management of the production means. The network is managed with more flexibility to reach the supply/demand balance in controlling production and consumption;
3. **To predict the production** of the RES to achieve by anticipation an optimal switchover towards conventional electricity plant and storage.

The two first ones were realized through the two R&D platforms presented previously. The third one, the forecasting of intermittent energy resources, is absolutely necessary for an optimal management of the energy fluxes through the system and to anticipate the future events.

Some works are realized on the forecasting of solar irradiance and PV production at short term (from 15 min to 6 hours) using Artificial Intelligent Methods such as Artificial Neural Networks, Regression trees, Random forests, …these works are used in a Horizon 2020 project called Tilos with as objective to maximize the utilization of intermittent renewable systems to cover the electricity need of the Tilos island (Greece). To reach this goal two main topics are:

- The development of a hybrid system PV/Wind turbine with a new technology of battery storage.
- Development of a smart-grid for an optimal energy management.

The development of hybrid electrical/thermal and of building integrated solar collectors is also an important topic developed in the laboratory and allows to participate to a COST action TU1205.

CONCLUSION

The research on Renewable energy is realized since 1981 in the University of Corsica: beginning with
studies on thermodynamic solar plant and progressively turned to the integration of intermittent and stochastic renewable energy plants into small electrical grid; the main topics are forecasting of solar resources production, optimal management of solar systems and smart grids.

Two important R&D platforms are available and allow to test in real conditions the results obtained from computational and theoretical researches.