# STAND ALONE POWER SYSTEM COUPLING A PV FIELD AND A FUEL CELL: FIRST EXPERIMENTAL RESULTS

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A stand-alone power system coupling a PV field, an electrolyser, a gas storage and a fuel cell should become an environmentally friendly solution to produce the required energy in remote sites. Advantages of that system are a possible complete autonomy, the no-consumption of fuel and no-emission. Different points have to be estimated to increase the knowledge of those systems such as the system efficiency, the intrinsic consumption, the reliability, the security, and the running cost. Two systems have been installed through the PV-FC SYS project. The former is installed at the Centre d'énergétique in Sophia Antipolis and presents many innovations to optimise the system operation and the later coupling commercial products is built in an industrial environment at Agrate.
The paper will present the description of the test bench built at Sophia Antipolis, and the first experimental results of the complete system.

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Hybrid systems based on the synergy between renewable energy sources and conventional energy systems (mostly Photovoltaic/diesel systems) are known to be a reliable solution for the electricity supply of remote sites. Nevertheless, such a solution is not yet the ideal one, as the use of a conventional system induces emissions of both exhaust gases and noise that have to be drastically reduced when looking for environmentally friendly solutions.

The purpose of the work, through the PV-FC-SYS project, is to optimise the operation of the following solution:

- Replacement of the conventional system by a Proton Exchange Membrane Fuel Cell (PEMFC), keeping the system reliability of supply at the same level while decreasing the environmental impact of the whole system.
- Introduction of an electrolyser, powered by the Photovoltaic (PV) generator, to produce the fuel for the PEMFC.
- Gas ($H_2$ and $O_2$) storage that can be sized for seasonal operation thus increasing the performance ratio of the renewable production.
- No battery for energy storage, avoiding the presence of a component, which still remains the weakest point of PV systems.

Such a hybrid system is intended to maximise the use of the renewable energy production and in a near future to decrease the current level of investment and running costs (a decrease by 10 to 100 is expected for PEM fuel cells within less than 10 years with forecasted costs down to 100 Euros/kW).

Gas storage capacity, for both short and long term, is analysed in term of its influence on the optimal use of the solar energy. The use of the stored $H_2$ and $O_2$ is meant to increase the system efficiency when compared with system using $O_2$ from compressed air.

Such a system can be also used for cogeneration. The heat balances will be calculated and the heat production for domestic purposes will be evaluated.

A prototype has been built at the CENERG in Sophia Antipolis (France). The test bench is used to assist the development of all the tools dealing with modelling, simulation and energy management, necessary to allow an optimal design of pilot systems adapted to remote sites. It also shows several innovations improving the system efficiency.

Moreover, a pilot plant is currently being installed at the Agrate site (Italy) of ST Microelectronics in an industrial environment. The aim of the PV-FC SYS European project is to develop and study these two plants. The partners are ARMINES (F), Transenergie (F), Vandenborre Technologies (B), Trivea (L), ST Microelectronics (I) and Iset (D). A French project with ADEME, Transenergie, ARMINES and Ainelec helps for the PMU development.

The paper will present the description of the test bench built at Sophia Antipolis (see figure 1), and the first experimental results of the complete system.

The electrolyser and the fuel cell have already been tested and they operate safely and automatically by the way of a security automat. The efficiency (see table 1) of the two electrochemical devices varies with the temperature (increase) and with the current (decrease).

The final step of the test bench realisation is the connection of all components (PV field, electrolyser, fuel cell, security batteries, instrumentation). The central component is the Power Management Unit, which insures the conversion and the management of energy between each component and provides AC power to the load. Specially designed for the application, this device is made up of 4 DC/DC converters, 1 DC/AC converter and a management microprocessor (see figure 2).

The most important experimental results are the system efficiency in the different cases that can be reached all the year long. These first results will be shown distinguishing the different situations occurring during the test period. Three months of experimental results are expected.

Other essential results are the intrinsic electrical consumption, the pure water consumption on which the system autonomy will depend and the security aspects. The reliability and the running costs will be evaluated after several months of operation.

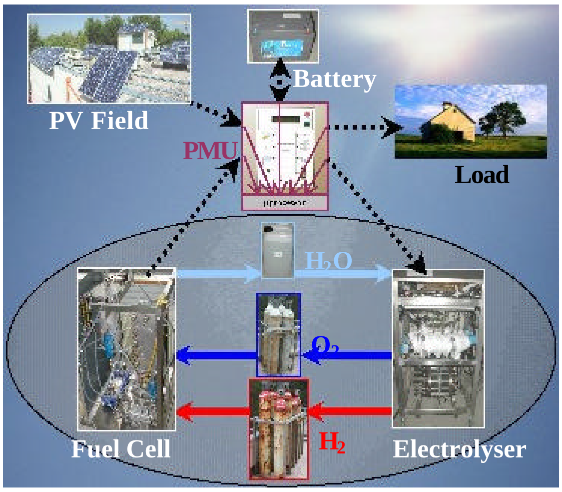


**Figure 1 :** The PV-FC system in place at Sophia Antipolis(F) (dotted arrows: electrical connections; full arrows: $H_2$, $O_2$ and $H_2O$ transfers)

**Table I :** Efficiency of the fuel cell and the electrolyser

| Component | Energetic efficiency (Based on High heating value) |
|---|---|
| Electrolyser | 77 % < ? < 95% |
| Fuel Cell | 40 % < ? < 60 % |

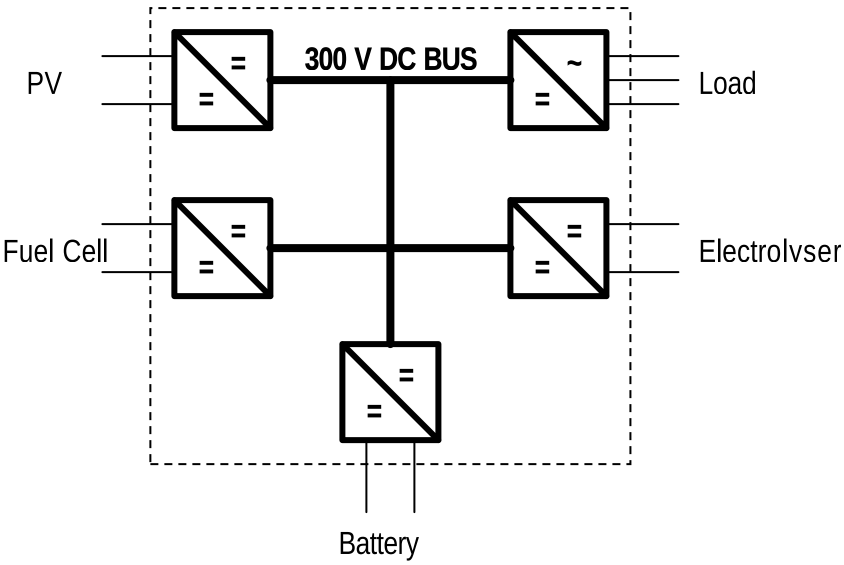


**Figure 2:** Electrical design of the PV-FC system