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Hybrid Installation to Cover Isolated Electrical Consumptions with Hydrogen Storage (IH2 Project)

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1 Introduction

The continuous need of energy supply to a dwelling requires reliable generation sources; one of the most important concepts is the no interruption of the energy. Moreover, the society demands clean energy sources to care the environment. One possible solution for this topic is the combination of electrical storage with renewable energy. This storage provides an amount of energy for periods in which we cannot produce energy from renewable sources.

There are several alternatives to storage energy: in the form of electromagnetic energy, kinetic, electrostatic potential... [1]. Among them we can highlight the chemical energy of hydrogen by their unique characteristics. Hydrogen is the most abundant element in the universe. It can be produced from the electrolysis of water with electricity, or biomass for thermal or biological decomposition, as well as from the fossil fuels like gas, oil or coal.

Between all methods, we can notice the electrolysis as a method to get hydrogen from renewable way, at any scale of production, and a possible housing facility. Once produced, hydrogen is an energy carrier. Hydrogen can be used in stationary applications (power generation) and / or cogeneration systems, and also for mobile applications, i.e., vehicles that run on hydrogen.

The Aragon Hydrogen Foundation launches IH2 like a demonstrative project for the technical integration of renewable energy with hydrogen as energy vector. It was decided to undertake a small project for possible integration into real small power applications , such as communication systems, houses, mountain huts, and in general, small installations where the power supply is not feasible.

The targets have been met by performing the system design, equipment selection, integration and assembly equipment, studies and other patterns that are described in more detail below:

1. Design and development of the plant balance, to supply electricity to a house to meets the demand, using photovoltaic as the main source of energy, a small support wind generator and hydrogen like energy vector.
2. Survey of the different connections types for the hydrogen production with photovoltaic and his storage. Integration, installation and implementation of the project.
3. Equipment testing and evaluation
4. System development of control and data acquisition [2,3].
5. Analysis and processing data acquired with varying levels of production consumption in order to extrapolate results to different power systems.
6. To develop criteria to improve the efficiency, reliability and security of the project

2 IH2 Project Installation

The following figure shows the installation scheme:

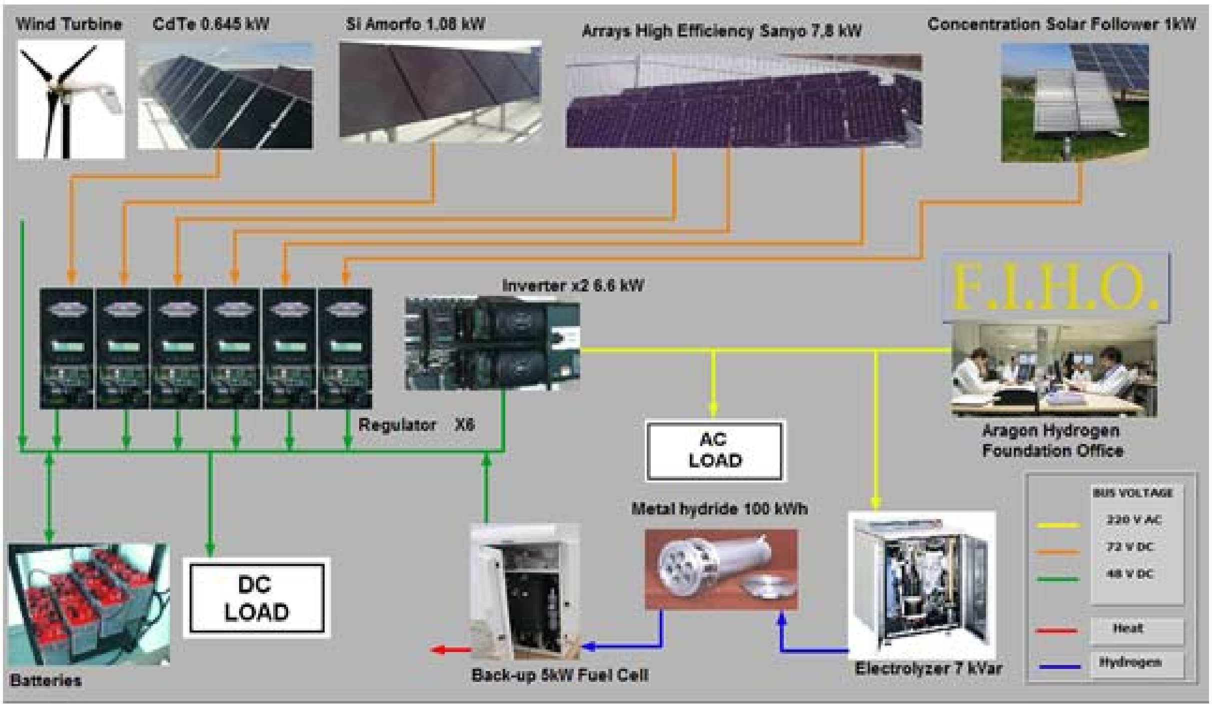

Figure 1: Installation scheme.

Electrical installation consists of a solar system that is placed around the Foundation's building. It is composed of fixed photovoltaic panels on the roof and solar concentrator at the front) and a micro wind turbine. The detailed generator list is:

1. 7.6 kW high efficiency panels. Divided in three arrays.
2. 1 kW sun concentration tracker with tree layer photovoltaic technology.
3. 0,7 kW thin film (TeCd) photovoltaic panels.
4. 1 kW amorphous silicon photovoltaic panels.
5. 400 W, Air X wind turbine

All electrical generators produce direct current (DC), the photovoltaic panels work in the optimum point coupled with Pmp regulators. A small bank of batteries is coupled to be actuated as an energy buffer. Two inverters transform DC it into AC to feed powering electrical charges and electrolyser.

1. Electrical equipment:
2. Regulators (Outback MX60),
3. Charger/inverters (Outback VFX3048E),
4. Batteries (Exide OPZ 460 Ah)

Hydrogen produced by the is stored in metal hydrides with a maximum pressure of 14 bar. During periods of lack of energy sources or at night, a 5kW fuel cell runs to power the system. The detailed hydrogen component list:

1. Electrolyze (HOGEN 0.5m^{3}N/h) and water treatment

2. Fuel cell PlugPower SB48 Power: 5kW
3. Labtech Metal-Hydride 15m^{3}N, 5m^{3}N per bottle of 3 installed. The amount of energy can be approximate to 66kWh

In order to use the amount of energy produced, the office of the Aragon Hydrogen Foundation has been connected to the installation acting as an electric load.

3 Monitoring Program

A comprehensive monitoring system has been developed [4]. It is combined with the research orientation to opens the door to many behavioural studies of the plant: under different load profiles, response with the weather conditions, system failures etc. The monitoring system has been developed in LabVIEW. It is flexible enough to be implemented in other applications with only minor modifications.

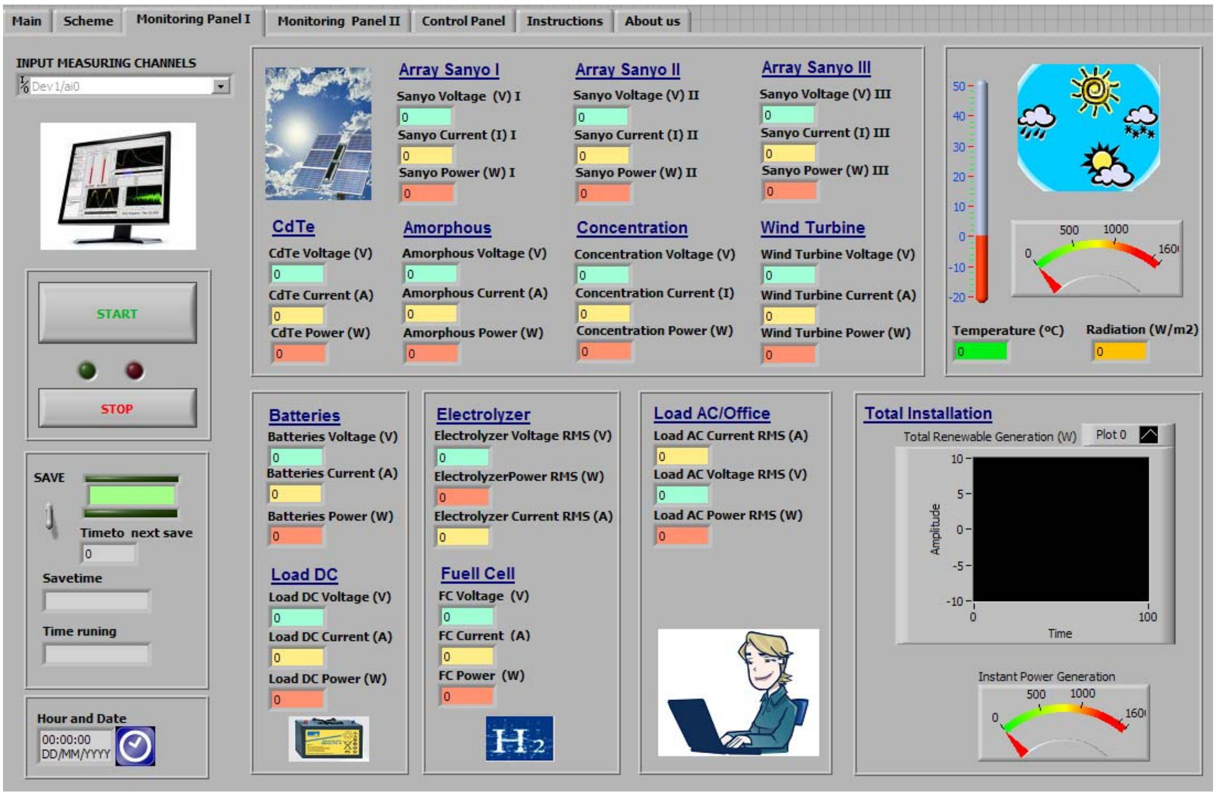

Figure 2: Screen capture of monitoring program.

Figure 2 shows that at electrical installation it has been measured the following variables: Voltage, Intensity Power, Temperature and Radiation. It allows to analyze the installation response with weather variability. At the hydrogen part the following measures have been developed: Temperatures, Pressure, Flow in order to obtain PFT graphics to characterize capacity, load and unloading operations.

A control panel and a hardware have been installed and developed in order to control electric loads. The main purpose is to probe different control systems and algorithms.

4 First Test

During the first part of the experiments, all equipment has been tested individually to verify the right work, as in the case of wind turbine, photovoltaic panels and electrolyze. The next part of the work plan is on the way, and the first results have been processed. They consist of different tests between many devices connection topologies and the energy supplied by the different generators. Furthermore these measurements allow to compare different technologies to choose the most efficient.

The next graphs show the results feeding the Aragon Hydrogen Foundation Office during a week. The first graph shows renewable energy generation by the different technologies installed. Next chart shows the energy balance during this test.

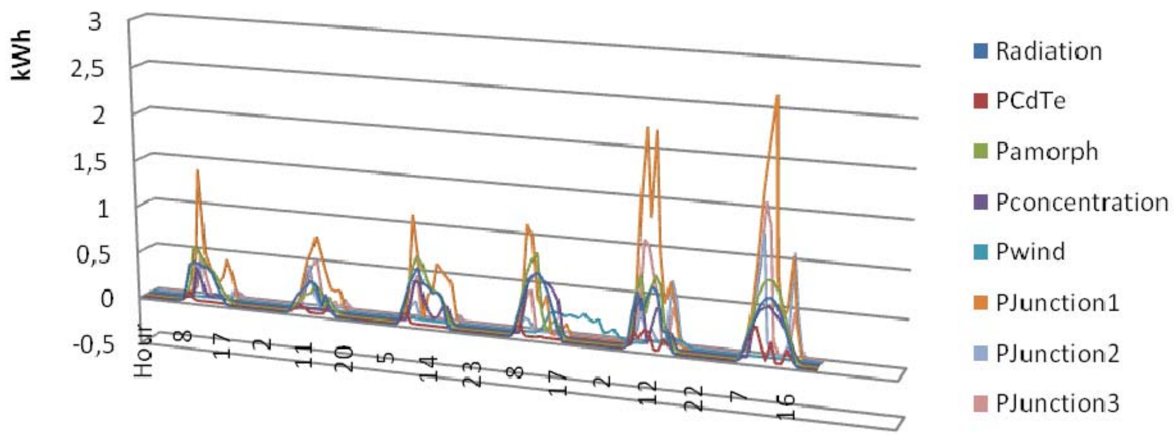

Figure 3: Renewable generation.

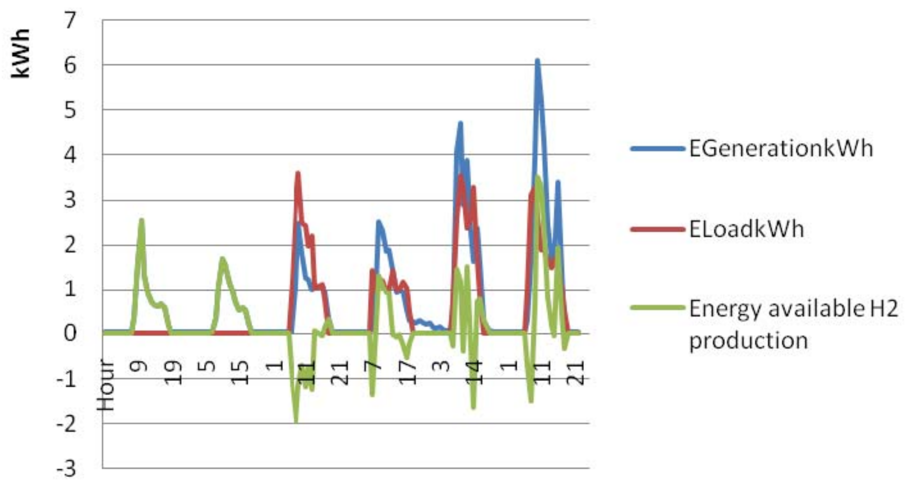

Figure 4: Energy balance.

Last chart involve Hydrogen generation and the real amount of energy available to store it in metal hydrides [5,6].

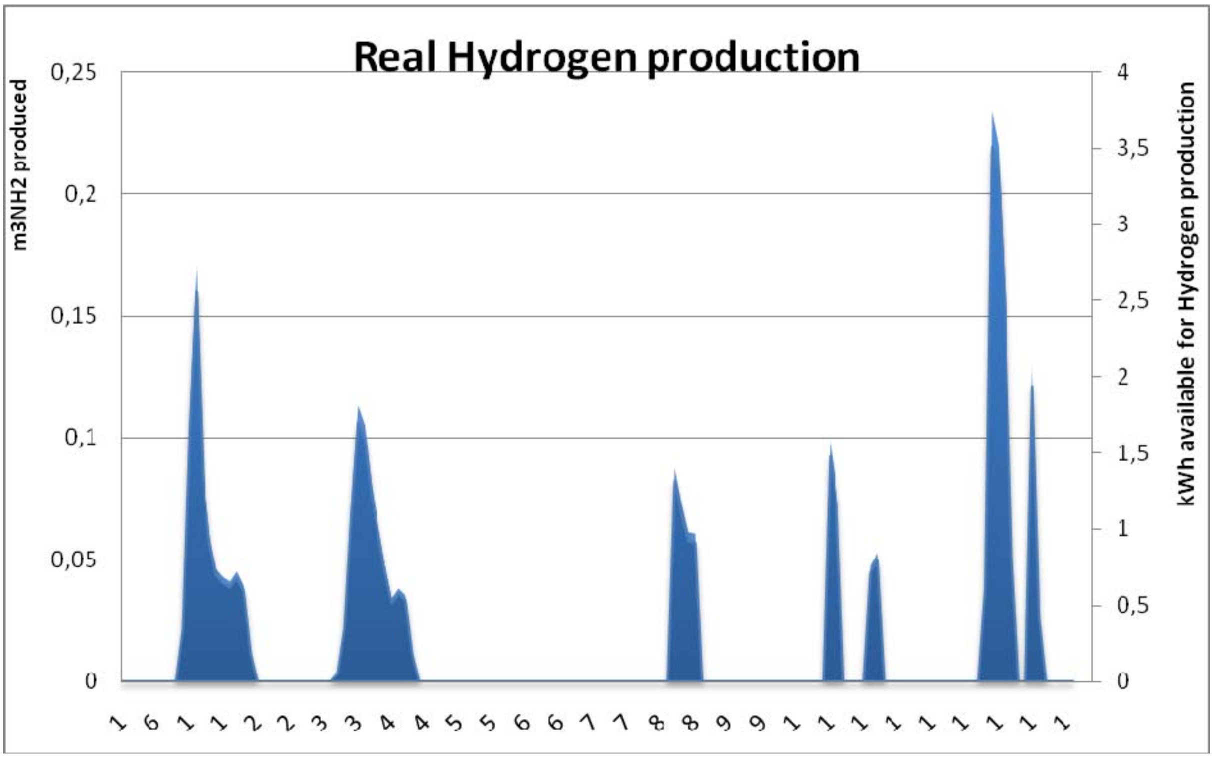

Figure 5: Real Hydrogen production.

5 Conclusions

A real installation and a complete monitoring system have been developed to analyse the system under different conditions. It has been checked that the installation works correctly. Besides the feasibility of producing green hydrogen from photovoltaic and wind energy in a real isolation conditions has been demonstrated. On cloudy days and nights, the small bank battery is used. If it is not sufficient the main support of the hydrogen fuel cell feed the load using the hydrogen generated by renewable energy when the weather conditions make it possible.

Real tests are in progress and the first results are shown in this paper. Moreover, it is important to realize, that the energy produced in the installation is being consumed by the Aragon Hydrogen Office.

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