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Remote Telecom System Including Photovoltaic Energy and H_2 Production by Electrolysis

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Abstract

The use of renewable energy is growing in significance due to exhaustion of fossil fuel and the environmental risks of its extensive use. There are a lot of applications in which fuel cell advantages play an important role as in the remote telecom applications.

There are thousands of units of telecom equipment without possibility of grid connection. These equipments are usually fed with photovoltaic panels, using batteries as energy storage systems that require to oversize these systems. The utilization of hydrogen to operate PEM fuel cells could let to reduce the size of this subsystem.

The objective of the project is the creation an independent system based on the use of PEM fuel cell in order to supply energy for a telecom system. It includes an electrolyser, and the hydrogen produced will be stored in metal hydride canisters for a final use into a fuel cell.

1 Introduction

We all know that we are heading to a shortage of energy sources, particularly fuel oil. The developed countries are directing their energy policies towards three fundamental parameters, these are the following: to ensure the fuel supply, the fulfilment of environmental agreement and economical competitiveness. The energy situation in Europe including the future energy demands and the few sources of own energy force the European economy to take a position of high risk. The combination of using solar-based energy generation and hydrogen as an energy carrier and storage offers a sustainable solution to many aspects of the energy issues, including transport and electricity generation. The hydrogen could be the dominant fuel, converted into electricity in fuel cells, leaving only water as waste product. Hydrogen is the most abundant element in the universe but it is not really an energy source like oil and coal because it is almost never found in its pure form. It must be released from chemical compounds. One method is to separate the oxygen and hydrogen from water by using electricity, a process known as electrolysis. As chemical reaction is reversible, the combination of hydrogen and oxygen will produce energy and water. This is the process used in an energy device known as a fuel cell. The most important aspect of this entire process is to produce hydrogen very economically. The hydrogen is not freely available in nature in large quantities, so it must be produced by conversion of other energy sources, including fossil fuels and renewable energy. Only renewable based hydrogen production can contribute to CO_2 emission reduction. Current renewable production methods of hydrogen include H2 production from biomass, from water by electrolysis (where the electricity has been produced by wind, solar or hydro energy).

2 Hidrosolar H_2

2.1 General description

The installation's main feature is its great modularity. The modularity will allow us to form it in different ways depending of the weather conditions and the parameters which we want to change.

The installation is designed to provide electrical energy to a remote telecom system. The energy primary source is the sun and the PV panels provide energy from solar radiation to storage system as electricity. We have two methods of energy accumulation: lead acid battery system and hydrogen storage system by metal hydrides.

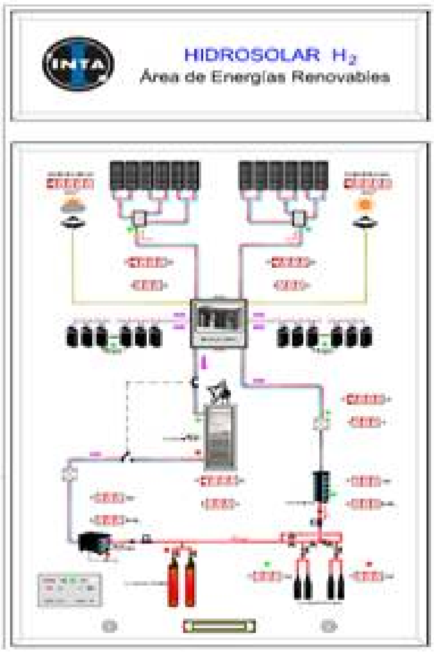

Figure 1: Hidrosolar H_2.

This last subsystem of storage needs the addition of a fuel cell which transforms the hydrogen to electrical energy when the installation needs it.

All the installation components are described in tables 1 and 2:

Table 1: Subsystem 1.

System element	Characteristics
6 PV panels	1.5 Wp, slope 60º, south
12 batteries	Lead-acid 6 EAN 55
Control system	Download data and control performance
Telecom system	Load 145 W, Load peek 197 W

The subsystem 1 is used to feed the telecom system by means of the traditional system and it will be helped by the batteries of the subsystem 2 in case of running out of energy.

Table 2: Subsystem 2.

System element	Characteristics
6 PV panels	1.5 Wp, slope 60º, south
12 batteries	Lead-acid 6 EAN 5
Control system	Download data and control the performance
Telecom system	Load 145 W, Load peek 197 W
Inverse DC/AC	Performance max. 93%
4 hydrides metal canister	Capacity max. 940 l and pressure between 3.5 and 17 bar
2 pressure hydrogen canister	Auxiliary.
Fuel Cell	1200 W, pressure hydrogen 0.7 to 18 bar
Electrolyser	300 VA max., hydrogen flow 0.5 l/min.

The subsystem 2 is dedicated to the production of hydrogen by electrolysis. Normally the batteries supply energy to the electrolyser, the hydrogen is stored in hydrides metal canisters and, when the load requires it, the hydrogen is going to fuel cell to produce the electrical energy necessary to feed the remote telecom system. The only exception is when the subsystem 1 has not the necessary energy and the subsystem 2 lends its batteries to feed the load.

2.2 The characteristics of the main components

The photovoltaic panels are connected to provide a peak power of 1.5 kW and nominal voltage of 24 V with 12 modules, 6 modules of 2 series panel. They are solar modules of ATERSA, with 7.28 A. and 17.48 V. in mpp.

The PV modules are connected to a lead acid battery system with a capacity of 396 Ah. This system is composed by 24 batteries, 12 connected in series to provide energy to load and 12 connected in series to provide energy to electrolyser. Each one has a voltage of 2 V, therefore 12 batteries for total voltage system of 24 V.

The electrolyser has been developed by SCHMIDLIN. The electrolyser employs the newest membrane technology available for electrolytic production of pure hydrogen gas. This technology is preferred over alternative hydrogen generating techniques because is clean and requires less maintenance. Furthermore, an auto shut off procedure places the unit in standby in the event of an internal error and selectable alarms allow the user to be informed whenever operating conditions vary from the set point.

Metal hydrides are certainly the safest way to store flammable hydrogen gas. The Ovonic Metal Hydride has been developed by Ovonic Fuel Cell Company. Typical metal hydrides are powders. When these metal powders absorb hydrogen to form hydrides, heat is released. Conversely, when hydrogen is released from a hydride, heat is absorbed.

Figure 2: PV panels.

Figure 3: Electrolyser.

The absorption process consists of Hydrogen gas molecules (H_2) stick to the metal surface and break down into hydrogen atoms (H). The hydrogen atoms then penetrate into the interior of the metal crystal to form a new solid substance called a "metal hydride". The metal atoms are usually stretched apart to accommodate the hydrogen atoms. The physical arrangement (structure) of the metal atoms may also change as the hydride forms. The desorption process. Hydrogen atoms migrate to the surface of the metal hydride, combine into hydrogen molecules (H_2) and flow away as hydrogen gas. The metal atoms contract to form the original metal crystal structure.

The absorption is similar to the storage of electricity from a battery. The advantages are the following: fast and simple charge, even after prolonged storage, high number of charge/discharge cycles, good low temperature performance and good load performance.

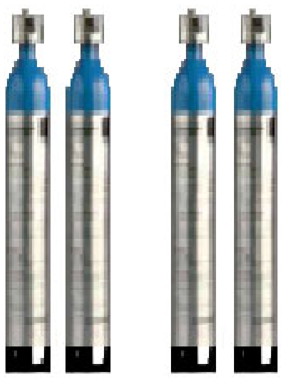

Figure 4: Hydrides metal.

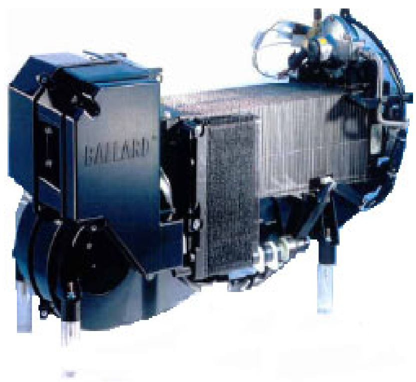

Figure 5: Fuel Cell Ballard.

The Nexa power module contains a BALLARD fuel cell stack, as well as all the ancillary equipment necessary for fuel cell operation. The fuel cell provides up to 1200 watts of unregulated DC power at a nominal output voltage of 26 Vdc. It is extremely quiet and produces zero harmful emissions. The fundamental component of the Ballard fuel cell consists of two electrodes, the anode and the cathode, separated by a polymer membrane electrolyte (PEM fuel cell).

The PEM fuel cell stack operates at low pressure, minimizing parasitic losses, reducing noise and enhancing system reliability.

The Nexa fuel cell stack architecture does not require external fuel humidification and it is air-cooled. Furthermore, it will shut down if a cell failure or a potentially unsafe condition is detected in the fuel cell stack.

In order to control all the system we have a programmable robot, which is included within a synoptic. This synoptic indicates us the system state at any time because it contains a scheme of the installation and by means of LEDs (LEDs green) it indicates us the state of each element (ON/OFF).

The working of Hidrosolar H_2 is testing the use of PEM fuel cell in remote telecom application. When the right operation was assured in the laboratory, it was integrated to the rest of the components in the test field.

To monitor the performance of the whole system, specific software is developed from t2s S.L which is included in the programmable robot.

After the big difficulties encountered during the integration phase with the fuel cell due to its sensibility to the operational parameters we are in phase of data analysis in operational period, studying the results and the possible causes of bad operation system.

The monitorization is able to assure the security and an effective control because it communicates via telephone in case of any unexpected trouble.

3 Preliminary Simulation

TRNSYS 16 was used to simulate the Hidrosolar_H2 system. TRNSYS is used by engineers and researches around the world to validate new energy concepts, and it allow us simulate the behaviour of our installation.

As a previous step to the whole TRNSYS simulation, all installation elements were validated. To determinate the most efficient configuration of Hidrosolar H_2, the system was simulated changing some characteristic parameters. The final conclusion was that the optimum configuration is using the hydrogen part of feed system as an auxiliary energy in periods of time with little solar radiation. In periods of time with much solar radiation the load is feed by PV panels, the excess of radiation is stored as hydrogen, mainly in summer.

4 The Future Project

Within the immediate future of the project several routes of performance are planned. The first one will be the change of the system parameters; in order to evaluate the possible reduction of batteries and PV panel's size, evaluate the minimum hydrogen required, the endurance of the fuel cells, and so on. This fact will suppose an increase of the feeding capacity of our installation and it will be possible to be directed to locations with greater consumption.

The second one will be the components optimization to achieve the dynamic management of energy.

Later, if we shall obtain an economically profitable installation, it will be studied the possibility of introducing this system in the energy market to feed a remote system without possibility of grid connection.

5 Conclusion

Although the simulation recommendation gives us a different configuration, we are interested in the behaviour of the hydrogen subsystem, and by that reason, we oblige the installation control to work with the half of PV panels in the hydrogen subsystem (feeding the electrolyser).

When the installation had been working during a year we would have data enough to configure the system parameters again within the most efficient installation. Furthermore, the system modularity will help us to change the configuration whenever we need.

The use of hydrogen with PV panels instead of diesel generator decreases the pollution and the maintenance activity and increases the availability of the telecom equipment.

Although the behaviour of this system during the summer period will show us the panels size is bigger than it needs, at the beginning this configuration is the best option to assure the necessary hydrogen production that will feed the load during winter period.

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