RES2H2 Project

Keratea, Greece & Pozo Izquierdo, Spain

The Cluster Pilot Project for the Integration of Renewable Energy Sources into European Energy Sectors Using Hydrogen, known as RES2H2, involves the integration of wind energy with hydrogen technologies—electrolyser, storage, and fuel cells—and water desalination by reverse osmosis. The project, financed by the Fifth Framework Programme of the European Commission, has installed two demonstration prototypes at test sites in Greece and Spain. The prototypes are self-sufficient energy systems driven by wind energy, capable of producing "green" hydrogen for energy storage and for supplying electricity and fresh water.

Objectives

The RES2H2 project is focused on the following goals:

- Increasing the penetration of wind energy in weak electricity grids.
- Optimizing integrated systems of wind energy and hydrogen.
- Advancing the technical and economic feasibility of the production of hydrogen from wind energy on a commercial scale.

Approach

Greek Test Site

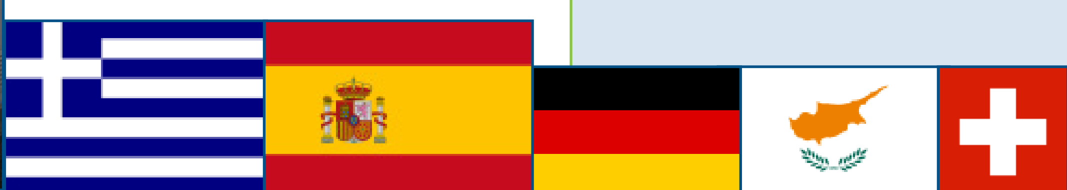
At the Greek test site, the plant was designed to study hydrogen production and storage integrated with wind energy. The prototype system is composed of a 25 kW water electrolyser, six metal hydride tanks filled with a $LaNi_5$-type alloy with a 3.6 kg hydrogen capacity, and a hydrogen compressor for filling hydrogen cylinders, all powered by a 500 kW synchronous wind turbine. The advanced alkaline electrolyser produces a maximum of 0.45 kg of hydrogen per hour directly at 20 bar pressure, which is compressed up to 220 bar in a single stage with an additional 10% energy loss. A 7.5 kW proton exchange membrane (PEM) fuel cell was recently integrated. The hydrogen was initially used only to supply experimental hydrogen vehicles but was later also used to fuel the PEM fuel cell in periods of low wind. Activities at the Greek test site are supported by a national project called Excellency and are also integrated with the national Renewable Energy Park project, which includes educational displays of different renewable energy technologies.

Spanish Test Site

The prototype installed in Spain was designed to satisfy the electricity and water needs of a theoretical isolated village. During the initial testing phase, the system was connected to the grid. The performance data collected during this phase defined the appropriate wind turbine system capable of satisfying the demands of the project in stand-alone mode operation.

The grid-connected system has been in operation since 2007 at the Instituto Tecnológico de Canarias, S.A. (ITC) facilities in Pozo Izquierdo, Gran Canaria, Spain. This location is exposed to the trade winds and creates an excellent testing environment. When electricity supply exceeds the theoretical demand, an alkaline electrolyser uses excess electricity to produce 0.99 kg of hydrogen per hour at 25 bar (5,500 Nm^3, or normal cubic meters, of storage) and the reverse osmosis plant also uses this excess electricity to produce a maximum of 110 m^3 per day of desalinated water. When power from the wind turbine does not cover demand from the electrical loads connected

Test site in Pozo Izquierdo, Spain



Project Overview

What

RES2H2 Project: Cluster Pilot Project for the Integration of Renewable Energy Sources into European Energy Sectors Using Hydrogen

Who

Instituto Tecnológico de Canarias, S.A., Spain

When

Started: February 2002
Completed: October 2007

Participants

Lead Countries
Greece, Spain

Partner Countries
Cyprus, Germany, Switzerland

Renewable Technology

This project demonstrates hydrogen produced from wind electrolysis.

Application

Vehicles and renewable energy storage

Website

http://www.res2h2.com

Contacts

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to the system, the stored hydrogen is used in six 5 kW PEM fuel cells to produce electricity.

Accomplishments

Greek Test Site

The performance of the electrolyser, compressor, and metal hydride tanks was assessed under different operating strategies, and the optimum conditions of integrated operation were determined. The power supply to the electrolyser varies in a range of 20 to 100% of its nominal power, but the compressor operates only in an on-off mode. By filling in cascade the modular high pressure section, the energy loss for compression is drastically decreased. Electrolytic hydrogen without purification is stored in three of the six metal hydride tanks, in order to avoid a 5 to 8% hydrogen loss in the purification section and to study the effect of oxygen and humidity impurities on the cycling capability. The results show that the efficiency of the system, from wind power to the high heating value of hydrogen stored, varies from 50 to 70%.

Spanish Test Site

At the Spanish test site, dynamic and stationary testing of all components has been performed to obtain the efficiency, range of operation, power consumption, transient response, and the operation curve of the fuel cells and electrolyser. The response of the components to typical wind power variations and their interactions with the rest of the system have been analyzed. A plan for converting from the current grid-connected system to a stand-alone system has been developed, and an initial topology of the stand alone system has been designed.

Lessons Learned

The main conclusion regarding both sites is that the potential for optimization of the electrical interfaces among the individual components is very important. More R&D is necessary in the field of power electronics for the integration of the wind turbine and the hydrogen system (i.e., electrolyser, fuel cells). This would address, in particular, the harmonics distortion generation that creates electrical instabilities and malfunction in the electrical system of the stand-alone solution. Also, in remote locations, the plant should not only be protected against a direct lightning surge, but also from secondary lightning currents. (The computer in the control room of the Greek site was destroyed by such a current). Concerning specifications for fuel cells, the impurities present in electrolytic hydrogen should also be addressed: a small amount of oxygen and humidity content should be tolerated to avoid the cost and losses of a purification section.

At the Spanish site, it was concluded that careful integration of the SCADA system with the main control system is important to synchronize each component's control strategies with an intermittent wind energy source.

At the Greek site, metal hydride tanks presented some benefits: during intermittent operation, they may be charged almost completely without external cooling with a concomitant savings in cooling energy. Also, they can be charged with electrolytic hydrogen that by-passes the purification section, which represents some 30% of the total cost for alkaline electrolysers and a 5 to 8% hydrogen loss for all electrolysers. The effect of the oxygen and humidity content of the hydrogen on the cycling capability of the metal hydride tanks is still under investigation, but the eventual regeneration of the tanks toward their end-of-life may be a more cost-effective solution than the installation of a deoxidizer and drier. However, the inertia of the system, that is, the time and energy required to heat up the whole mass of the tank, makes them difficult to incorporate in a fully automatic system. This is because the response of the system largely depends on the state-of-charge and the ambient temperature for external storage.

Future Plans

At the Greek site, the cogeneration capability of the fuel cell will be used to supply heat to the metal hydride tanks in order to avoid the use of an electrical boiler and further increase the efficiency of the integrated system. Other plans include the modification of a gasoline vehicle to run on hydrogen, the revamping of the electrolyser by installing a more potent power supply, and the upgrade of the compressor to 350 bar or higher.

Test site in Keratea, Greece

Test site in Pozo Izquierdo, Spain

International Partnership for Hydrogen and Fuel Cells in the Economy