Utsira Wind Power and Hydrogen Plant

Utsira Island, Norway

In 2004, the small windswept island of Utsira, Norway, became home to the world's first, full-scale combined wind power and hydrogen plant.

In this pilot project, 10 households were supplied exclusively by the energy generated from wind turbines. In windy weather, the turbine powers the houses directly. When the wind power production exceeds the households' demand, the excess power is used to produce hydrogen in an electrolyser. The hydrogen is compressed and stored, and when the winds are either too mild or too strong to generate enough energy from the turbine, a hydrogen engine and a fuel cell uses stored hydrogen to produce the necessary electricity. This system ensures a continuous and reliable energy supply to the homes for up to three days when wind power is not available.

Objectives

By developing and testing a full-scale, wind-hydrogen energy system, this project aimed to demonstrate how renewable energy can provide a safe, continuous, and efficient energy supply to remote areas.

With this project, owned by Statoil ASA and operated in collaboration with German wind turbine manufacturer Enercon, the two firms want to ensure that the installed components in the system worked together—to deliver power to the customers with the expected quality; to reduce costs and optimize the technical solutions of the project; and to commercialize and market the production method.

Approach

The frequent wind at Utsira made the island an ideal location for wind power production. Two Enercon E40 wind turbines were installed at Utsira, each with a capacity of 600 kW. One turbine produces electricity for the external grid only, while the other is connected to the stand-alone system and is pitched down to approximately 150 kW to better match demand. To stabilize the intermittent renewable energy, a flywheel with a 5 kWh capacity and a 100 kVA master synchronous machine are installed to balance and control voltage and frequency. In order to store the surplus energy, a 10 Nm^3/h Hydrogen Technologies electrolyser with a peak load of 48 kW, a 5 kW Hofer compressor and a 2,400 Nm^3, 200 bar hydrogen storage pressure vessel are installed. To generate power when there is no wind, or too much wind, a 55 kW MAN hydrogen internal combustion engine and a 10 kW IRD fuel cell were installed.

Project leader Torgeir Nakken, from Statoil's R&D center in Porsgrunn

Project Overview

What

Utsira Wind Power & Hydrogen Plant

Who

Statoil ASA & Enercon GmbH

When

2004-2008

Participants

Norway, Germany

Renewable Technology

This project demonstrates hydrogen production through wind electrolysis.

Application

Renewable energy storage

Website

http://www.statoil.com/en/NewsAndMedia/Multimedia/features/Pages/HydrogenSociety.aspx

Accomplishments

Utsira is practically offshore—one hour with the local ferry from the nearest town running three times a day – and weather conditions are often severe. This has required solid engineering and meticulous project execution. The wind turbines had to be installed before the autumn storms, and roads and a small port were constructed for equipment transportation. After start-up, the facility was remotely operated from an inland power plant control center.

The project was operated continuously for four years, with more than 50% of the time in stand-alone mode. The power quality was very good, and, with no complaints reported, the customers seemed to be satisfied. The project also had a public education aspect including involvement in local activities, good media coverage, articles in several publications, and a number of presentations at conferences and at industry fairs. In 2004, the Utsira project won the prestigious Platts award for "Renewables Project of the Year" in New York City.

Lessons Learned

Despite the successful demonstration and operation of the system, several challenges were identified. In this project, the wind energy utilization was only 20%, revealing a need for the development of more efficient electrolysers, as well as improved hydrogen-electricity conversion efficiency. The fuel cell experienced some technical problems that did not allow it to be fully integrated into the system, including leaking of the coolant fluid, damage to the voltage monitoring system during assembly, and frequent false grid failure alarms. In addition, the fuel cell experienced very rapid degradation even when idle and was operated for less than 100 hours over the duration of the project. These issues, combined with the low efficiency of the hydrogen engine and increased electricity use by customers over time, heightened the probability that hydrogen would run out during windless periods. The contingency plan was to connect the customers back to the grid if this happened so that they would not be without power.

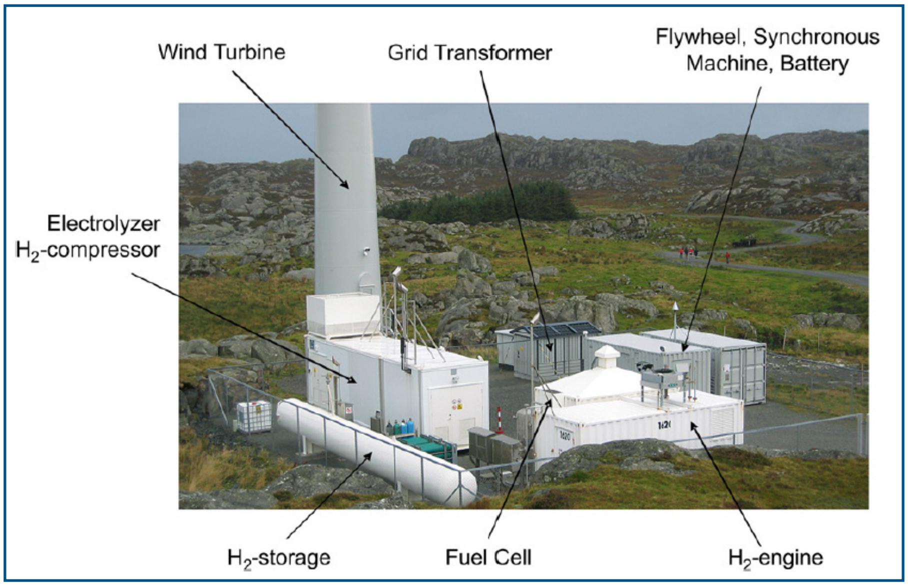
The hydrogen engine provided more than three years of reliable service but eventually experienced some technical problems and had to be replaced. Although the engine was seen as a good, near-term solution, project leaders concluded that the cost and durability of the fuel cell would have to be improved to make this type of project commercially viable. They also recommended that future projects include more than one renewable energy source (i.e., wind, solar, and/or bioenergy).

The following points were identified as the most important considerations in planning, building, and operating such a project:

- Having a well-defined design basis and operational philosophy focusing on climatic conditions, signal quality, communication (control and regulation), and key component interfaces.
- Keeping safety, health, and environment in mind—it is important to use equipment with a high degree of fail-safe and remote operation capability.
- Selecting an appropriate location with good wind conditions but that is not too remote; a small but representative load; a back-up system in place; a supportive community, and access to service personnel.

Future Plans

The success of the Utsira project in demonstrating the feasibility of combining renewable energy and hydrogen in remote locations opens new opportunities for the application of electrolysers in future energy systems. One goal of the Utsira project was to see if the wind-hydrogen concept could be made commercially feasible. Though much tweaking will have to be done to achieve this goal, the time frame to be competitive with conventional remote-site power supplies—diesel or combined wind and diesel generators—has been estimated to be about five to 10 years.



Utsira wind/hydrogen demonstration plant

International Partnership for Hydrogen and Fuel Cells in the Economy