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Safety strategy for the first deployment of a hydrogen-based green public building in France

F. Verbecke*, B. Vesly

Quality, Health, Environment and Safety Department, HELION – AREVA Group, Domaine du Petit Arbois – BP71, 13545 Aix en Provence Cedex 04, France

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ABSTRACT

HELION, a subsidiary of AREVA in charge of the business unit Hydrogen and energy storage, is deploying for the first time in a French public building, a hydrogen-based energy storage system, the Greenergy Box™. The 50 kWe system is coupled with a photovoltaic farm to ensure up to 45% electrical autonomy and power backup to the building. The safety system and siting measures of the complete hydrogen chain are described. The paper also highlights the work accomplished with Fire Authorities and Public to gain the acceptance of the project and allow the deployment of four other hydrogen-based green buildings.

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1. Introduction

The future belongs to Renewable Energy Sources (RES), and satisfying the energy growing demand for sustainable energy sources must be one of the highest priorities for research in the energy field. Four main electricity storage applications can be distinguished for RES management:

- Load levelling – to allow smoothing the RES power plant output (Fig. 1 left).
- Time shifting – to store electricity during low demand periods and feed in the grid when demand is high and/or electricity prices high.
- Forecast optimization uses the storage system as a buffer enabling a real-time RES production as scheduled – for example in PV or wind 24 h' forecasts (Fig. 1 right).

- Grid stabilization and system services: storage systems based on hydrogen can act as secondary and tertiary reserves for grid frequency and voltage regulation

Hydrogen presents many advantages for storage of the RES, in particular:

- PEM electrolyser are suitable for high dynamics from RES e.g. wind and photovoltaic;
- High pressure electrolysis i.e. 35–50 bar allows the production of gaseous hydrogen and oxygen without further compression stage which implies lower investment costs and higher simplicity of the system;
- H₂ and O₂ are both stored and used to produce electricity back in an H₂/O₂ fuel cell;
- O₂/H₂ fuel cells are air independent system and present a better output compared to Air/H₂ fuel cells

* Corresponding author.

E-mail addresses: franck.verbecke@areva.com (F. Verbecke), benoit.vesly@areva.com (B. Vesly).

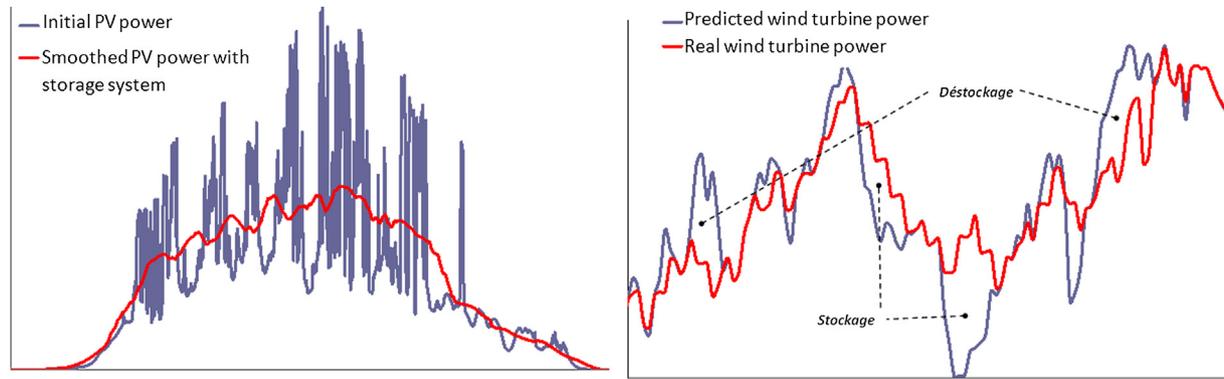


Fig. 1 – Storage system allows smoothing the RES power plant output (Left); Forecast optimization uses the storage system as a buffer enabling a real-time RES production as scheduled – for example in 24 h forecasts (Right).

- Carbon free electricity production without toxic compounds;
- Noise free;
- High efficiency when combined with power and heat production;
- No self-discharge over time;
- Independent optimization of the system delivered power (fuel cell power: kW) and of the available stored energy (gases storage: kW h).

2. Deployment of the Greenergy Box™

2.1. Energy context

A number of cities located in the South of France face the problematic increase of population by a factor 10 in summer. Furthermore, some of them may be exposed to repeated power outage on account of the end line location on the electrical network. In this context, they target the objective to be more electrically independent from the network.

2.2. An innovative project

The project aims at developing hydrogen-based energy storage solution coupled with photovoltaic panels for five buildings in order to:

- Insure the green production of electrical and thermal energy for five buildings of the city
- Ensure the partial energy autonomy of the buildings and backup system in case of power outage
- Decrease the energy bill of the city while continuing in the sustainable development
- Develop a reliable and sure solution that can be transmissible to the future generations

The project is partially autofinanced, thanks to the electricity produced by the photovoltaic panels that is sold back to the French electricity provider EDF.

The Greenergy Box™ [1], developed by HELION-AREVA [2], is the hydrogen-based energy storage system that has been chosen to be coupled with photovoltaic panels to answer to

the energy problem of the city. The first Greenergy Box™ is going to be installed in a Children's Leisure Centre.

2.3. The GREENERGY BOX™: the solution for the project

The Greenergy Box™ is a containerized hydrogen chain comprising an electrolyser, a fuel cell, water and heat management, and electrical converter systems coupled with hydrogen and oxygen reservoirs installed out of the container. The Greenergy Box™ is an integrated modular system that can offer a power from 50 to 500 kW with a storage capacity from 0.2 to 2 MW h. Several systems can be coupled to increase the power and the energy capacity. Coupled with RES, such solution allows not only ensuring a partial building autonomy from 45 to 85% but also providing the function of backup system for several hours at high power.

The photovoltaic panels provide electricity to the electrical network and the surplus is used by the electrolyser to generate gaseous hydrogen and oxygen, as shown in Fig. 1. Once produced, gaseous hydrogen and oxygen are stored within separated reservoirs installed outside of the Greenergy Box™. It is thanks to the fuel cell system that the stored hydrogen and oxygen can be used to produce electricity to ensure partial energy autonomy of the buildings as well as the backup system in case of power outage. The Greenergy Box™ manages itself the electricity received by the photovoltaic panels to electrolyse water or to provide electricity to the network. Furthermore, heat, which is also produced by the system during both electrolysis and hydrolysis processes, is also managed and valorized for the adjacent buildings.

The water-proof and wind-resistant Greenergy Box™ is segregated into three different compartments, including in particular an electrical, a fuel cell compartment and an electrolyser compartment as shown in Fig. 2.

The Greenergy Box™ system is currently being tested on HELION's site as shown in Fig. 3 below. The development of such solution enables HELION to offset the remaining barrier to the full deployment of renewable energies: their intermittency.

2.4. Sizing for the Children's Leisure Centre

The Children's Leisure Centre is going to be equipped with a 200 m² photovoltaic panel farm installed on the roof,

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