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CUT-IN NOTE

Analysis of the barriers for the hydrogen energy technology in stand-alone power systems

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Abstract

The integration of hydrogen technologies in renewable energy systems of remote areas is expected to be a challenging development in the foreseeable future, since hydrogen can be generated and stored in large quantities, can be produced on site, does not produce polluting gas or other emissions and has a high energy content (enthalpy) per unit weight. However, such development has to overcome significant barriers, such as high capital cost and limited experience and availability of equipment. Nevertheless, there is a large potential for applications and so a normal market development, with reducing costs, can be expected. This paper presents the results and recommendations of an international workshop on market potential analysis for the introduction of hydrogen energy technology in stand-alone power systems.

1. Introduction

The EU policy on hydrogen and fuel cells is currently under development, leading to the creation of the European Hydrogen and Fuel Cell Technology Platform. The platform should assist in the efficient co-ordination of European, national, regional and local research, development and deployment programmes and initiatives and ensure a balanced and active participation of the major stakeholders (i.e. industry, scientific community, public authorities, users, civil society). It should help to develop awareness of fuel cell and hydrogen market opportunities and energy scenarios and foster future co-operation, both within the EU and at global scale[1] .

[1] European Hydrogen and Fuel Cell Technology Platform: http://www.HFPeurope.org

The development of hydrogen applications is strongly depending on the availability of energy, so if the first priority is the sustainability of the hydrogen systems, large quantities of renewable energy are required, much more than the 22,1% of the EC Directive 2001/77 on electricity.

This paper presents the results and recommendations of the workshop on market potential analysis for the introduction of hydrogen energy technology in stand-alone power systems (H-SAPS), which was hosted within the 1st European Hydrogen Energy Conference, 2-5 September 2003, Alpexpo-Alpes Congres, Grenoble, France [1].

The main aims of the workshop were:

- to present the market potential results of the H-SAPS project supported by the ALTENER programme of the European Commission, DG for Energy and Transport;
- to discuss these results with major market players. During the workshop about 40 highly qualified people participated actively in identifying this market potential.

2. Hydrogen & Renewables in Stand-Alone Power Systems

In general, hydrogen is advantageous because it can be stored in relatively large quantities, it can be produced on site, it does not produce any polluting gas or other emissions and has a high energy content (enthalpy) per unit weight.

From the point of view of the electrolyser industry:

- the products are still in the prototype and demonstration phase
- issues that have been addressed and seem adequate for use in H-SAPS are: short start-up times, quick response times, low demand for maintenance, improved hydrogen gas quality, simple installation and operation, integrated controls and power conditioning, modular and flexible design, possibility for increased pressure output (already demonstrated up to 138 bars, so reducing the need for compressors, especially for smaller H-SAPS systems).
- Regenerative fuel cells considered advantageous for H-SAPS because of high specific energy, low maintenance and longer lifetime.
- Cyclic operation of >100 low earth orbit (LEO) cycles successfully undertaken for regenerative systems (sums up to some 200 hours of cyclic operation).

The Proton Exchange Membranes (PEM) for use in electrolysers are not yet available commercially, due to issues concerning cycle stability and costs. However, progress has been made in demonstrating regenerative systems, which meets the critical parameters for *stand-alone power systems (SAPS)* in a very promising way. SAPS in the range of 1 to 5 kW capacity could be one of the most promising markets for the installation of small fuel cells.

3. The H-SAPS Market Study

Electrolysis units installed in SAPS should not use much power when idling and have short start-up times. The latter is less critical due to the decoupling of generation and load, and to the possibility of forecasting both load and weather conditions for generation (e.g. wind). The only technologies that meet such requirements now are alkaline and PEM electrolysers. The main disadvantages are that the cost of small electrolysers is still large and no major market for small electrolysers exists.

Three different storage options (compressed hydrogen, liquefied hydrogen and metal hydrides) were evaluated in the H-SAPS project. For operation in a SAPS, the following storage parameters were examined: energy efficiency, costs, response times, safety, controllability, complexity and lifetime. Compressed hydrogen storage from generation at 20 bars, and so without using a compressor, seems the most adequate solution for H-SAPS.

For small systems, generation and load fluctuations are prominent. Potential hydrogen power generation devices in this project therefore comprise: fuel cells (PEM and alkaline), gas turbines and Internal Combustion Engines.

The main segments of this market (by demand and supply side) are:

A High consumption consumers looking for alternative forms of supply
B Conventional SAPS without grid connection
C Settlements totally without electricity

The main external factors affecting the introduction of hydrogen in SAPS are:

- general political climate regarding renewable energy sources (RES)
- energy mix for RES
- fiscal measures and subsidies for RES
- energy market structure for RES
- Gross Domestic Product
- unforeseen factors (war, natural disasters etc.)

The future of the hydrogen technologies is promising, but the following topics seem to be prerequisites:

- Research and Technological Development (RTD) oriented at the demand and the needs of the market;
- pan-European cooperation to face the worldwide competition;
- integration of the RES & hydrogen systems in order to combine the benefits of both RES and hydrogen technologies;

- creation of stronger synergies between developers, suppliers and the European Commission [2].

4. Results and recommendations

To evaluate the introduction of hydrogen technologies in SAPS, i.e. H-SAPS, a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was conducted [3, 4, 5]. The analysis was based on information collected from questionnaires, experience of the technical staff of H-SAPS consortium and other sources (literature, personal contacts with hydrogen technologies providers etc.) (tables 1 and 2).

Table 1
The SWOT of H-SAPS

Strengths	*Weaknesses*
• No need for fuel transport infrastructure. • Already existing experience in handling of compressed gases. • The main competing systems are noisy (e.g. Diesel Engine Generator Sets). • Potential for high density energy storage. • Seasonal energy storage without energy loss. • Able to handle power fluctuations and therefore ideal for integration with intermittent RES. • Guarantied power from a RES system. • Potential for small and predictable O&M costs • Reduced environmental impact compared with conventional energy sources • Safety of power and energy supply	• Missing codes and standards (safety issues, technical specifications, etc.). • Technology immaturity of fuel cells and PEM electrolysers. • Poor availability and large cost of small electrolysers. • Lack of after-sales support. • Procurement cost. • Lack of component and system life-time experience. • Weak supply network (consultants, engineers, entrepreneurs, etc). • Few dedicated complete system deliverers. • Safety concern of users and authorities.
Opportunities	*Threats*
• Already existing SAPS driven by RES in which hydrogen technologies can be incorporated. • Current EU and national financing schemes. • New job opportunities. • Diversification of companies involved in the energy sector.	• Potential end-users have no experience • No public available market study for SAPS in EU. • Inadequate commercialisation plan. • Limited practical experience due to few true SAPS with hydrogen as an energy carrier (H-SAPS) installed.

• Reduction of environmental impact.	• Hydrogen as a storage medium for energy in SAPS is not known and accepted. • Inadequate legislative framework (standards, regulations, permissions of installation). • Low interest and priority from utilities and major suppliers of SAPS components / systems.

Sources for this analysis were as comments from

- Technology providers (RES, H_2 , Balance of Plant)
- Utility companies
- Research institutes including universities and state owned and private investigate facilities
- Energy authorities
- EU/national/regional/local authorities
- Users & user organisations
- Installers & owners
- Investors

The participants of the workshop concluded that countries such as Greece have a relatively large market potential for SAPS, especially for island and other remote communities. The excellent solar and wind resources at most such locations in Greece, would make H-SAPS solutions competitive. Today, most of the electricity production on Greek islands is by diesel sets, with expensive running and maintenance costs, leading to realistic opportunities for H-SAPS in the short to medium term.

Table 2

Actions to be taken based on the SWOT analysis

Strengths	*Weaknesses*
• Campaign promoting the benefits of H-SAPS • Training for the handling of liquefied hydrogen systems	• Development of codes and standards (safety issues, technical specifications, etc.) • More R&D to increase the maturity • Training of the traders for after sales support • Training of consultants, engineers, entrepreneurs, etc
Opportunities	*Threats (i.e. still required)*

• Development of the SAPS driven by RES in which hydrogen technologies can be incorporated • Exploitation of the existing EU and national financing schemes • Cooperation with companies involved in the energy sector	• Implementation of specific analysis and commercialisation plans • Increase the number of demonstration installations • Formulation of the appropriate legislative framework (standards, regulations, permissions of installation) • Cooperation with the utilities and major suppliers of SAPS components / systems

Perhaps the introduction of hydrogen in small SAPS will not be attempted by large European organisations, because of the relatively small market. Demonstration may come from idealistic wealthy individuals or from needy communities.

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