

“17th World Hydrogen Energy Conference Brisbane June 2008 “

## “WIND ENERGY & HYDROGEN INTEGRATION: Overview of IEA Hydrogen Implementing Agreement, Task 24”

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### Abstract:

Under the auspices of the International Energy Agency's Hydrogen Implementing Agreement, a working group has been evaluating and comparing experiences with green hydrogen production with wind energy. This paper presents an overview of Task 24 –Wind Energy and Hydrogen Integration– which has been underway since April 2007. There are currently 21 members from 9 countries working in four subtasks.

### Introduction

There is currently a broad interest in hydrogen production by means of renewable energy sources, as hydrogen is expected to be one of the main energy carriers in the near future. The IEA HIA has studied several possible renewable energy sources for hydrogen production. Within the current set of possibilities, water electrolysis by means of wind energy ranks high as a competitor to fossil fuel in terms of technical and economic feasibility.

Today, both water electrolysis and wind energy technologies are considered mature, although R&D efforts are still undertaken to enhance performance and cost savings in both technology fields. In principle, however, water electrolysis technologies were not conceived for such variable input conditions as those inherent to the nature of wind resources. Therefore, the current state of the art must be upgraded largely to avoid redundant power electronics. System integration improvements are expected to increase efficiency and reduce capital and O&M costs.

Although hydrogen applications are virtually unlimited, transportation and early markets in portable applications are expected to be near-term drivers for advancement of the hydrogen economy. At the same time, there is an interesting stationary application that arises related to wind energy and other renewable energies such as solar PV. Their inherent variable nature presents integration problems for market and grid operators. These conditions may retard their development in certain markets (e.g., wind energy in Denmark, Germany or Spain), where market penetration has already occurred. Storage systems can provide a solution to this problem by allowing wind energy to be stored closer to conventional energies, thereby increasing wind energy's capability to follow demand, guarantee a desired amount of energy, offer a flat curve or a more smoothed curve, etc.

The fully integrated wind and hydrogen application connects wind technology with various hydrogen related technologies such as electrolyses (for production), hydrogen to electricity converters (for utilization), and storage systems.

If wind farms can be coupled to energy storage systems, wind energy will become available to offset the growth in network capacity. Furthermore, wind farms would become multi-purpose, decentralized producers of either electricity or hydrogen for fuel when the automotive industry enters mass production of hydrogen-fuelled vehicles. In the short term, marginal but significant benefits can be obtained by improving dispatch ability and offering reserve power and grid services. In any case, the goal is to enhance the value of wind electricity itself.

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Another important niche market will be off-grid systems relying solely on renewable energy sources. It makes sense to include these systems in the scope of this annex due to the inherent high cost of off-grid power systems; their role as an early adopter application; and the reality that most current operational wind/hydrogen applications are serving off-grid applications. Projects have been developed or proposed in various countries. These represent a good starting point for learning experience since they include very different stakeholders from every segment of the value chain, including research institutions, equipment manufacturers, and utilities.

The principal drawbacks to an economically feasible wind-to-hydrogen concept are the costs of the main equipment, the diversity of regulations and promotions of wind energy from country to country, and the gap between prototyping and markets, both mass and niche. This task is divided into four subtasks:

**Subtask A: State of the Art**

In this subtask, the goal is to conduct an in-depth review of the current state of the art in wind turbines, electrolyses, and intermediate equipment, as well as a survey of market and electrical system regulation. A detailed review will also be performed that includes the current state of the art as well as lessons learned relative to hydrogen production using wind energy and fully integrated wind energy & hydrogen technology projects.

**Subtask B: Needed improvements & system integration. Technology development on main equipment and system integration concepts**

In this part of the study, the scope is focused on the two main components for hydrogen production, the wind turbine and the electrolyses, as well as the intermediate connecting components. The in-depth analysis will research a future technical optima. The goal of this subtask is not to provide an enhanced design for either equipment but to develop proper specifications.

- This subtask has to address the following issues:
- The dynamics
- Electrolyses durability under a very dynamic workload
- Development of specific wind turbines

**Subtask C: Business concept development**

This subtask will deal with:

- Economic assessment with a detailed hydrogen production cost study of different concepts within representative market conditions, and prognosis of the potential market size.
- Conceptual development and validation of layouts, extending to logistics and final use of the produced hydrogen, differentiating remote applications, weak grids, and large-scale wind generation. Two applications will be specially considered: hydrogen as fuel for transportation, and on-site conversion of hydrogen to electricity for grid balancing.
- Cross-cutting issues: social and environmental acceptability of increasing wind power capacity devoted to hydrogen production. Technical, environmental and market regulations affecting hydrogen production using wind power. An analysis of competing technologies should be included, as well as safety regulations.

**Subtask D: Applications. Emphasis on wind energy management**

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In this subtask, near term applications for the hydrogen produced shall be studied, with a special emphasis on one of the main applications pointed out in subtask C. This application is wind energy management within the wind & hydrogen full integration concept. Given the noticeable synergy between hydrogen and wind energy regarding their integration for a further approach of renewable energy sources with inherent non continuous and random nature, it is considered appropriate to deal with this application in a separate subtask.

An analysis similar to the ones performed in tasks A to C shall be performed for those components contributing to full wind energy & hydrogen that were not previously taken into account. These components are basically hydrogen to electricity converters such as fuel cells, internal combustion engines and gas turbines.

The key issue for such system integration is the development of a control and operation software that could enable wind & hydrogen integrated plants to operate in different conditions

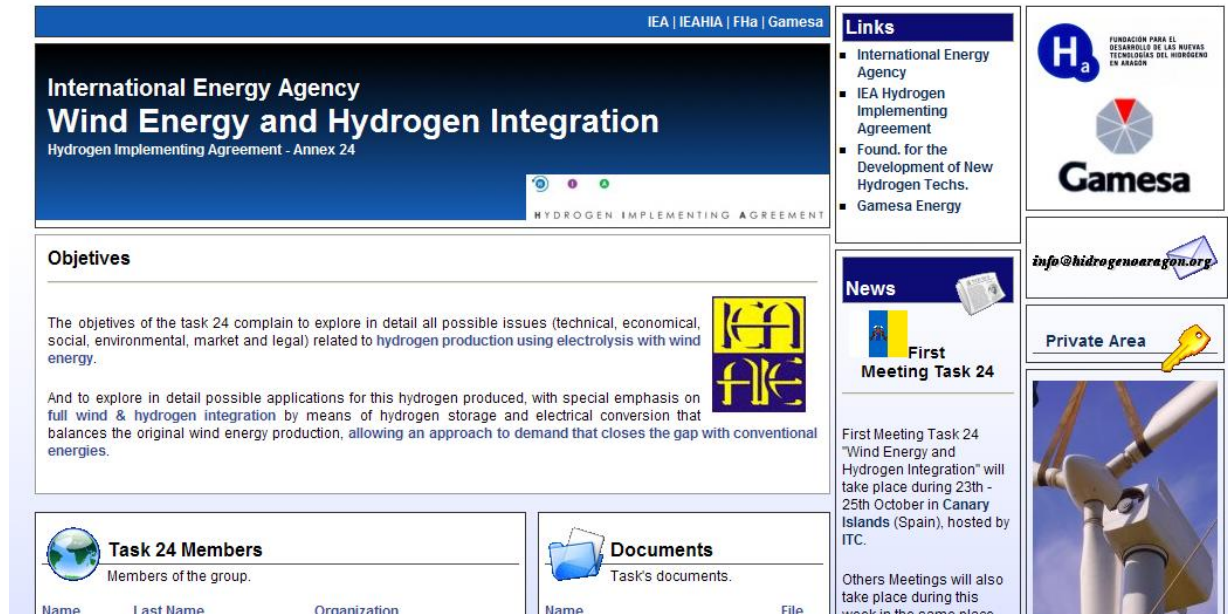
Cross-cutting issues: social and environmental acceptability of increasing wind power capacity versus other solutions (grid reinforcement, fossil and nuclear generation), comparative analysis of different technical, market and environmental regulations affecting wind power. The actual list of task 24 members is showed below:

	Name	Enterprise	Country
	<b>Opera gent Agent</b>		
1	Luis Correas Uson	Aragon Hydrogen Foundation	Spain
2	Ismael Aso	Aragon Hydrogen Foundation	Spain
3	José Ramón Largo	GAMESA	Spain
	<b>Subtask A Leader</b>		
4	Aaron Hoskin	Natural Resources of Canada	Canada
	<b>Subtask B Leader</b>		
5	Kevin Harrison	NREL	EEUU
	<b>Subtask C Leader</b>		
6	Jörg Linnemann	Planet GbR	Germany
	<b>Experts</b>		
7	Ernest Burkhalter	IHT	Switzerland
8	Eli Varkaraki	CRES	Greece
9	Javier Pino	Seville University	Spain
10	Salvador Suarez	ITC	Spain
11	Pablo Fontela	Endesa	Spain
12	Felipe Rosa	INTA	Spain
13	Ken-ichiro Ota	Yokohama National University	Japan
14	Sam Miyashita	ENAA	Japan
15	Claus Jorgensen	RISO	Denmark
16	Allan Schroeder	RISO	Denmark
17	Monica Aguado	CENER	Spain
18	Raquel Garde	CENER	Spain
19	suzanne shaw	EU	Europe
20	Rupert Gammon	Director, Bryte Energy Ltd	Uk
	<b>Contributors</b>		
1	Larry Moulthrop	Distributed Energy	USA
2	Geoff Dutton	H2NET	UK

Table 1- Task 24 Members

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A new web page for task 24 has been created, looking as follows:



The screenshot shows a web page for the International Energy Agency (IEA) focused on 'Wind Energy and Hydrogen Integration'. The page is titled 'International Energy Agency Wind Energy and Hydrogen Integration' and is part of the 'Hydrogen Implementing Agreement - Annex 24'. The main content area is in Spanish, with the heading 'Objetives' (Objectives). The text describes the goals of Task 24, which is to explore technical, economic, social, environmental, market, and legal issues related to hydrogen production using electrolysis with wind energy. It also mentions exploring applications for this hydrogen, with a focus on full wind & hydrogen integration. The page includes several sidebars: 'Links' with links to the International Energy Agency, IEA Hydrogen Implementing Agreement, Found. for the Development of New Hydrogen Techs., and Gamesa Energy; 'News' with a section for 'First Meeting Task 24'; 'Private Area' with a key icon; 'Task 24 Members' with a table for listing members; and 'Documents' for task documents. There is also a 'Gamesa' logo and an email address 'info@hidrogenoaragon.org'.

Illustration 1- Web page Task 24 (<http://task24.hidrogenoaragon.org/>)

## Recommended Reading

1. Title: Control Analysis of Renewable Energy System with Hydrogen Storage for Residential Application  
Authors: A. Bilodeau, K. Agbossu  
Issued by: Journal of Power Sources  
Date: 2005
2. Title: Wind-Hydrogen System Overview of System Components  
Authors: A. C. Vikis  
Issued by: Natural Resources Canada  
Date: 2005
3. Title: Exergetic Life Cycle Assessment of Hydrogen Production from Renewable  
Authors: M. Granovskii, I. Dincer, M. A. Rosen  
Issued by: Journal of Power Sources  
Date: 2007
4. Title: Comparison of electrical energy efficiency of atmospheric and high-pressure electrolysers  
Authors: Amitava Roy, Simon Watson, David Infield  
Center: CREST, Loughborough University  
Issued by: International Journal of Hydrogen Energy  
Date: 3 April 2006
5. Title: A Novel Design of a Low Cost, Robust, Efficient and Dynamic Electrolyser Optimised For Fluctuating and Intermittent Renewable Energy Powered Operation  
Authors: Amitava Roy, Simon Watson, David Infield  
Center: CREST, Loughborough University  
Issued by: International Congress of Young Scientists on Hydrogen  
Date: 18-21 May 2005
6. Title: Experience in the design, sizing, economics, and implementation of autonomous wind-powered hydrogen production systems  
Authors: A.G. Dutton, J.A.M. Bleijns b, H. Dienhartc, M. Falchettad, W. Huges, D. Prischichd, A.J. Ruddell  
Center: Rutherford Appleton Laboratory  
Issued by: International Journal of Hydrogen Energy  
Date: 1 August 2000.