



ITHER Project: “Green Hydrogen from Wind and Solar for Mobile Applications”

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“Wind Energy and Nature, Future CO₂=0”



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Sum up

The **ITHER project**, “*Technology Infrastructure for Hydrogen and Renewable Energies*”, promoted by the Foundation for the Development of New Hydrogen Technologies in Aragon, comprises a whole test and demonstration facility for photovoltaic, wind energy and hydrogen. This **4 M€** project developed during the last three years, has been completed in phase one in early 2008. Since December 2007 hydrogen from the sun is being produced.

The facilities display a complete picture of current PV and wind technology, consisting of a **635 kW wind farm** with three different turbines, a **100 kW grid connected photovoltaic** installation (three panel technologies, four different sun-tracking systems), and an isolated 2.7 kW photovoltaic application (1 kW concentrated PV, 1.7 photovoltaic roof with two advanced panel materials thin film and amorphous). The facility includes hydrogen production by a PEM and an alkaline electrolyser, storage (low pressure and high pressure) and fuel cells. Up to date, it is the only renewable-to-hydrogen project in the world that includes so many different technologies.

The hydrogen produced is used for mobile applications, for two end users: **20 hydrogen bikes**, and to feed a **hydrogen kart**, which take part in *FormulaZero* racing. *FormulaZero* (FZ) is an European racing that promotes a zero emissions karts championship based on fuel cell technology. The championship begins with a college edition, starting from bases and material support for teams (an 8 kW PEMFC). Different University teams (England, Holland, Belgium, USA and Spain) must conceive, design and manufacture a kart zero emission based on hydrogen and FC systems, testing their technological capabilities.

The **ITHER** project serves as showcase for renewable electricity and hydrogen production, for training and researching purposes at the Foundation, as well as for raising awareness on the future energy challenges. Recently, the Foundation for Hydrogen in Aragon and Swiss-based Company Industrie Haute Technology signed an agreement to jointly develop wind-to-hydrogen solutions in the range of **MWs**.

Introduction

The Foundation for the Development of New Hydrogen Technologies in Aragon is a private, not-for-profit entity, created to promote the use of hydrogen as an energy vector.

Promoted by the Government of Aragon, it was founded in **2004** with the support of the administration, industry and the main society actors from different sectors of activity. Twenty-eight entities, research centres and companies support the launch of this initiative, which is gaining new support year after year, which today has become a board made up of **63 members**, of key importance for the Aragonese economy. With the support of the board members, the Foundation works day by day for the development of new hydrogen technologies integrated with renewable



energies and the promotion of Aragon’s involvement in economic activities relating to the use of hydrogen as an energy vector.



Illustration 1 – Board Members

The aim of the **ITHER Project** is the start-up of an installation that allows tests of hydrogen generation by **electrolysis**, with electricity obtained from renewable sources, with the most diverse available technologies. The project tries to cover all the hydrogen chain (production, management and efficient use), obtaining the primary energy from renewable sources by means of processes currently available (photovoltaic and wind).

The secondary goal of the mentioned installation will be the **learning** of integration at real scale of renewable sources and temporary hydrogen storage, technological diffusion, "green" hydrogen generation of renewable sources for their consumption in stationary or portable applications, and evaluation of the efficiency and functionality of the transmission systems in AC current and continuous, all that in an operation frame that guarantees an economic return by the sale of the excess of electricity in Special Regime that facilitates the financing of the project and covers its operation and maintenance costs.

Project Description

The activities to be done within the framework of the present Project include the basic and detail projects, the supplying of the main equipment, and the construction and start-up of each one of the electrical subsystems and hydrogen:

1-Photovoltaic Generators: Installation of fixed panels: a **parking zone** has been built to obtain an efficient land use and to shade the parking, increasing the aesthetic of the



surroundings. There are 60 kW installed on the 3 marquees of the parking with a total of 300 panels, 210 Wp, monocrystalline, brand MSK, model TFC 210-W and 6 invertors of 10 kW each one, brand SUNWAYS, model NT 10000. Due to the direction of the marquees, oriented longitudinally towards the south, FV panels are perfectly oriented in that direction, nevertheless, although the maximum possible performance would be obtained with an inclination of 32°, by aesthetic and looking for the maximum architectonic integration, has limited the inclination to 15° of the marquees cover, assumed that the losses for this reason will be of a 3.15%.

Installation of panels in **sun followers**: the referred installation is constituted by four solar followers of two axes that allow the pursuit of the annual solar trajectory in inclination and azimuth with a nominal installed power of 40,000 W, and 44,568 Wp of power installed in panels, using different designs and pursuit technologies.



Illustration 2– Photovoltaic grid Installation.

The photovoltaic project, is completed by an isolated installation, with one 1 kW **sun concentrator**, and 0, 7 kW thin film and 1 kW amorphous panels on the roof, as appear in the pictures below.



Illustration 3-Photovoltaic isolated installation

2- Wind Turbines (Wind Farm R&D- 635 kW): It consists of **three different turbines**, each one with a type of technology and on an average range of powers (80 kW, 225 kW and 330 kW). With this infrastructure it is expected to be pioneering not only in Spain, but also at international level, due to the range of powers that are handled, constructing the infrastructure necessary to have a real test bench of hydrogen production by renewable energies.

This situation in the market of the turbines, is taking to the non-existence of models in the average range of powers (100 kW- 400 kW), which is entailing to the non-operation of the wind resource in those zones near the energy consumption, like can be farms, etc, due to the elevated



impact that would imply the positioning of the sizes of the turbines that are settling in the range of the MW at the moment.

Before this emptiness in the market of the turbines in the range of intermediate powers, the proposal that is made for the configuration of the Walqa Wind Farm is the reusability of turbines in the intermediate range of powers, that at the moment are being replaced by models of greater power, following the present tendency that has arisen at world-wide level from "re powering".

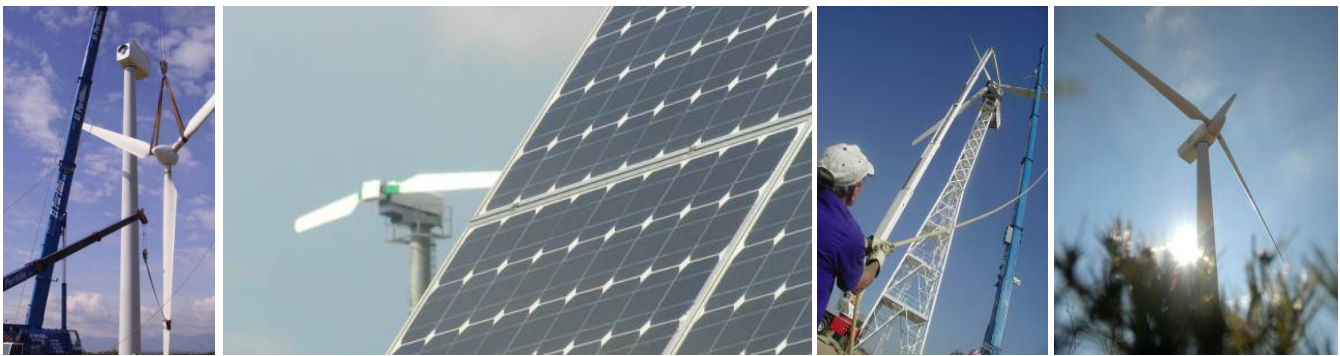


Illustration 4-Turbines

3 -Energy System Management: Includes the electronics of power (to turn the electrical power at acceptable levels for the electrolyzers), the control system and supervision (**SCADA**), the connection to the electrical grid to spill the excess of production, and the additional devices to improve the electrical power quality.

It has been chosen to divide this system in two: the interconnection to the grid (**Transformation Centre, CT**) and the interconnection to the hydrogen generation (**Distribution Centre, CD**). In order to calibrate properly the complexity of the **ITHER** Project it is enough to point out that there are not antecedents of a wind and photovoltaic mixed installation, which is the reason why the CT has certain innovating characteristics. Of course, the CD concentrates most of the innovation. Both centres will be located in individual buildings prefabricated in own parcel. Next are the Single-wire schemes of the CT, CD.

Electrical Connection CT, CD

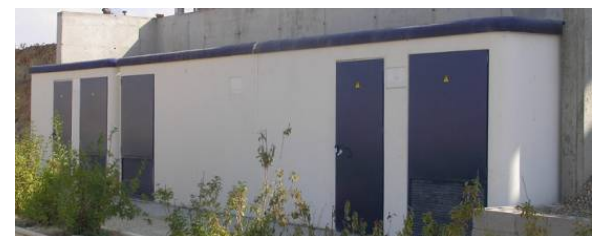
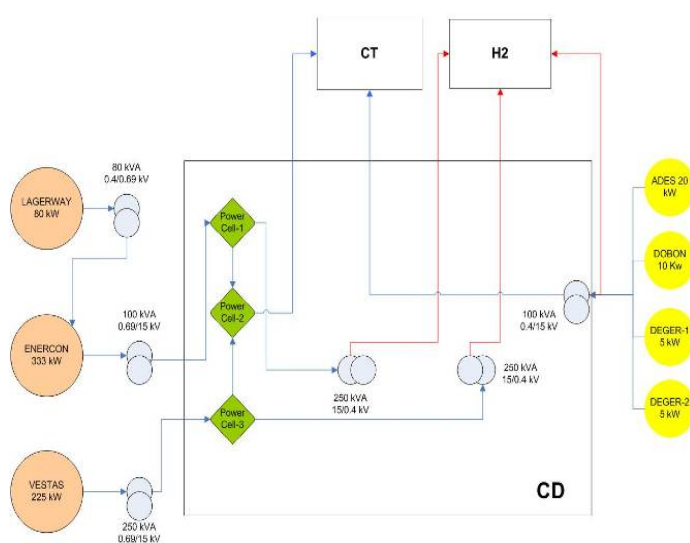


Illustration 5-Single-wire schemes CT,CD



4-Hydrogen generation and plant balance: it is foreseen to equip with the infrastructure for two electrolyzers, totaling about 70 kW of installed power, and to install two representative units of the two dominant technologies: PEM and alkaline.

The **PEM electrolyser** model is HOGEN 20, and results related to efficiency are show in the picture below

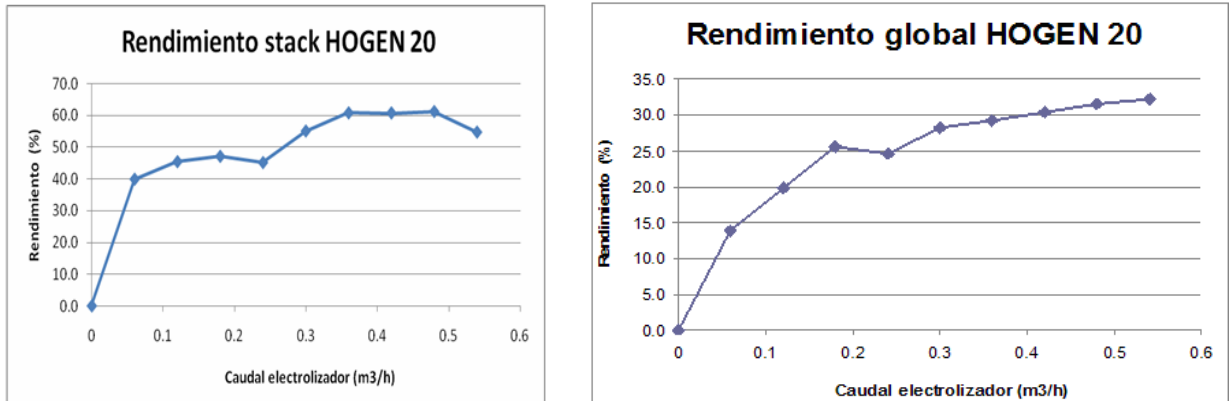


Illustration 6 –Left Stack Efficiency PEM electrolyze, Right global PEM Efficiency Electrolyze (HHV)

The elements of the plant balance (BOP) must be also considered: water demineralisation, hydrogen refrigeration and purification, etc. For the storage, the Foundation has 3 metal hydride storage tanks (LABTECH manufacture, a Bulgarian company, who which a **Development Agreement** has been signed) with a total capacity of 21 Nm³.

A complete metal hydride test bench has been built, with all instrumentation required pressure/temperature, etc sensors, control all of them by own Labview software developed.

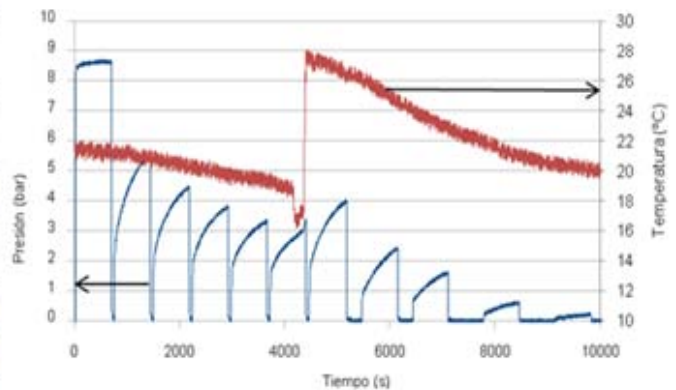


Illustration 7 - Metal Hydride Test bench

With **IHT** (Swiss Electrolyser Company www.iht.ch) is being developed a high pressure (32 bar) alkaline electrolyser to get a wind-to-hydrogen complete solution. In the picture below appears the stack for the **ITHER** project, this technology is able to reach large hydrogen production up to 760 m³ N/h (4 MW), which match with huge wind parks which are install nowadays, in the size of 20 MW. IHT is the only electrolyser manufacture all over the word able to produce large pressure electrolyser in the range of MWs.





Illustration 8 – Dhejva (Switzerland), Electrolyzer (4 MW, 760 m³ N/h,) 3rd Meeting Task 24 hosted IHT



Illustration 9 –Alkaline Electrolyze (400 V AC – 3.300 A DC, 18 V DC, 50 kW 10 m³ N /h, 32 bar)

The hydrogen infrastructure is being completed with a **hydrogen refuelling station** compound by following main equipments: a medium pressure buffer storage (4.000 l, 32 bar), high pressure HOFER diaphragm two stages compressor (350 bar, 10 m³ N/h), high pressure storage (350 bar, 6 gr), and a hydrogen dispenser. The start up is expected to be by the **beginning of 2010**.



Illustration 10 – Hydrogen refuelling station area



5- Hydrogen use for mobile applications: The hydrogen produced from renewable sources nowadays is used for mobile application such as: **20 hydrogen bike fleet**, which are been use for internal transport in the Walqa Technology Park, as can be seen in the pictures below:



Illustration 11 – Hydrogen Bike fleet for internal use

And also the green hydrogen is used to run the kart which takes part on **FormulaZero Championship** (www.formulazero.nl). Formula Zero is the new zero-emission race class for hydrogen and fuel cells vehicles, in which nowadays take part 4 teams: Zero Emission Racing Team (**Belgium**), UnizarTech2 (**Spain**), Imperial Racing Green (**England**) and Green-Choice Forze (**Holland**).

In summer 2009, four races took place each one in each country, and the UnizarTech2 team was classified in second position, below appear several pictures taken during the racing.

Furthermore, and thanks to the awarding of European funds, next year, **ITHER** project will count with two new hydrogen-powered vehicles to provide zero-emission mobility for the Technology Park where the Foundation is allocated.



Illustration 12 – Hydrogen Kart UnizarTech2, in Formula Zero Racing



6- Foundation Building: the Foundation has a land in the Walqa Technology Park (North-East of Spain) with a surface of 3,979.75 m². The building has an useful surface of 1,170.50 m². The distribution of the building allows the lodging of those Companies, Research Centres, Universities Departments that aims to research in the new hydrogen technologies.



Illustration 13-Aragon Hydrogen Foundation Research Center

Diffusion and Spreading

Thousands of people visited **ITHER** project each year, as it can see in pictures below:



ITHER Project: “Green Hydrogen from Wind and Solar for Mobile Applications”





Illustration 14 – Visits made to ITHER Project

Also **ITHER** project is shown in main hydrogen events worldwide such as: WHEC Brisbane 2008 (**Australia**), NHA 2010 Columbia (**USA**), Hannover Fair (**Germany**), VIII HYPOTHESE Lisbon (**Portugal**), Power Expo Zaragoza (**Spain**), etc

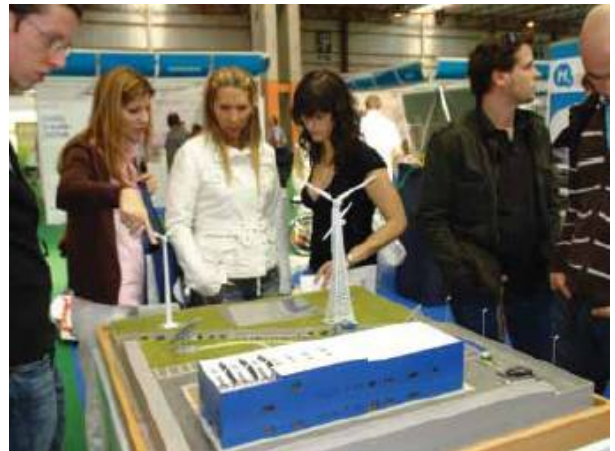


Illustration 15 – External ITHER Diffusion worldwide



In 2007, **ITHER** initiative was awarded with the Spanish National Industrial Engineering Award, His Royal Highness Prince Felipe de Borbón at the reception of the National Industrial Award 2007 with Mr. Arturo Aliaga, Regional Minister of Industry, Trade and Tourism of Aragon Government and President of Aragon Hydrogen Foundation.



Illustration 16- Spanish National Industrial Engineering Award 2007

International wind/hydrogen initiative Task 24

An international initiative was launched by Aragon Hydrogen Foundation in December 2006 called **Task 24 “Wind Energy and Hydrogen Integration”** (<http://task24.hidrogenoaragon.org/>), supported by the Hydrogen Implementing Agreement of the International Energy Agency (IEA HIA)

The objectives of Task 24 complain to explore in detail all possible issues (technical, economical, social, environmental, market and legal) related to hydrogen production using electrolysis with wind energy. And to explore in detail possible applications for this hydrogen produced, with special emphasis on full wind & hydrogen integration by means of hydrogen storage and electrical conversion that balances the original wind energy production, allowing an approach to demand that closes the gap with conventional energies.

Nowadays is compound by **25 experts**, belong to different countries worldwide such as Canada, USA, Japan, Spain, Denmark, Germany, Greece, England, Switzerland, etc. The kick off meeting took place in Walqa Technology Park, and **ITHER** project is one of the case studies taken as pilot action.



Illustration 17 – Kick-off meeting in Walqa Technologic Park Task 24 “Wind Energy and Hydrogen Integration” May 2007



Conclusions

ITHER project is the main bet of the Aragonese society in order to be on the vanguard of the hydrogen economy. The Region of Aragon has an important wind and solar resource that together with the hydraulic resource will allow reducing the external dependency that exists at the moment. Due to all mentioned before, the project is allowing to undertake new lines of investigation, such as:

1. Wind – Hydrogen, Photovoltaic - Hydrogen integration **tests and optimal sizing**.
2. **Durability and efficiency tests** in the chain of hydrogen production.
3. **Characterization and improvement of components**: turbine, electrolysers, compressor, etc
4. **Optimization** of mixed systems renewable-hydrogen and development of **control systems**.
5. **Improvement grid quality systems**, using part of hydrogen generated in engines or fuel cells.
6. **Hydrogen fuel cells integration** for Mobile application.
7. Development of **guidelines for operation and maintenance** of the system.
8. **Efficient use of hydrogen for electricity generation**, co-generation and tri-generation.
9. **Technical formation of personnel** in hydrogen technologies.
10. **Diffusion and spreading** of hydrogen technologies
11. **Case study for Task 24** “Wind Energy and Hydrogen Integration”

“Thanks IEA HIA for your support to our Foundation since beginning”



Illustration 18 – Hydrogen Master Plan in Aragon



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