ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/257939611

ENERGETIC ANALYSIS OF A HYDROGEN REFUELLING STATION IN SEVILLE PROVINCE DISTRICT

Conference Paper · July 2008

CITATIONS
0

READS
712

6 authors, including:

Felipe Rosa
Universidad de Sevilla
81 PUBLICATIONS **1,990** CITATIONS
SEE PROFILE

Luis Valverde-Isorna
Abengoa
26 PUBLICATIONS **936** CITATIONS
SEE PROFILE

Eduardo López
Instituto Nacional de Técnica Aeroespacial
56 PUBLICATIONS **266** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Project Improving efficiency and operational range in unmanned vehicles using fuel cells (IUFCV Project) View project

Project Experimental microgrid and renewable energy storage facilities at INTA's Energy Laboratory View project

All content following this page was uploaded by Eduardo López on 06 June 2014.

The user has requested enhancement of the downloaded file.

ENERGETIC ANALYSIS OF A HYDROGEN REFUELLING STATION IN SEVILLE PROVINCE DISTRICT. PROJECT HERCULES

F.J. Pino Lucena [(1)], *F. Rosa Iglesias* [(3)], *A. Iranzo Paricio* [(2)], *L. Valverde Isorna* [(2)], *E. López González* [(3)], *P. Bermejo Morillo* [(2)]

[(1)] Energy Department, Engineering School, University of Seville. Avd. Camino de los Descubrimientos S/N, Seville, C.P. 41092, fjp@us.es
[(2)] AICIA, Avd. Camino de los Descubrimientos S/N, Seville, C.P. 41092
[(3)] INTA, Crta. Matalascañas-Mazagón km.33, Mazagón (Huelva), C.P. 21130

Corresponding author: fjp@us.es, +0034 954487259

Abstract

In 2006, HERCULES Project was launched with two objectives. First, design and build the first hydrogen refuelling station at South of Spain, in Seville province. Hydrogen will be produced via an electrolyser connected to a Photovoltaic Field. Second, change internal combustion engine of a SUV vehicle into an electric engine fed using a PEM Fuel Cell. Hydrogen produced at station will be consumed by the electric vehicle. Project Hercules is promoted by several partners: Santana, Hynergreen, Abengoa Solar, INTA, AICIA, Carburos Metalicos, GreenPower and Agencia Andaluza de la Energía.

The objectives of this article are: describing the hydrogen refuelling station and analyse it, taking into account solar radiation, hydrogen production and estimated consumption by vehicle, and electric consumption of auxiliaries (compressor and dispenser).

Keywords

Hydrogen production, fuel station, electrolysis, simulation

Introduction

Today, hydrogen technology for vehicles is in a vicious circle since, on the one hand vehicle manufacturers definitely not bet on this technology, among other reasons, because there is not a network of refueling stations to supply hydrogen to vehicles when facing a long shift. On the other hand, gas companies do not do any investment in refueling stations, among other reasons because there is no number of vehicles based on hydrogen technology to justify that investment.

In some countries, including United States, Japan and Germany, there is already a network of refueling stations enough for experimental hydrogen based vehicle fleet moving by these countries [1]. In Spain, there are currently only two seasons refueling operating, one in Madrid and another in Barcelona. There is being built one at the site of Expo Zaragoza 2008, and at the last is presented in this article in Seville province. These stations are expected to create some niches for development and testing hydrogen vehicles, and also, check refueling stations operation and perform safety studies for future commercial stations, suitable for all users.

System Description

The hydrogen refueling station is located in Sanlúcar La Mayor (Seville), and is next to existing Abengoa photovoltaic and thermoelectrical solar plant.

Figure 1. Abengoa Solar plant in Sanlúcar La Mayor [2]

Goals of the Hercules project are the next's [3]:

1) To study the viability of integrating an industrial electrolyser in an intermittent energy generating environment–solar energy. In principle, the choice has been made for an alkaline electrolyser, as these days these are the main ones that run reliably in the industry.
2) Set up the electrolysis plant and hydrogen compressor in order to operate on an almost uninterrupted basis, filling up the storage tanks to a pressure of 400 bar - double of standard pressure for hydrogen storage in an industrial installation.
3) Design hydrogen refueling equipment to fill a vehicle's tank quickly, with gas that is always available on demand.

In order to reach these goals, hydrogen refueling station has next lay-out, represented in Figure 2. A Two-axes tracked photovoltaic field of 63 kWp Power (photovoltaic panels are from different companies) feed electrically an alkaline electrolizer of 67 kW with a nominal hydrogen production of 10 Nm^3/h (max. 12,5 Nm^3/h). Hydrogen produced at 6 bar is compressed to 200 bar using a pneumatic compressor in a compressed storage tank of 100 Nm^3. Dispenser takes hydrogen from storage tank and compress it to 400 bar ,and after, storage it in a short vessel.

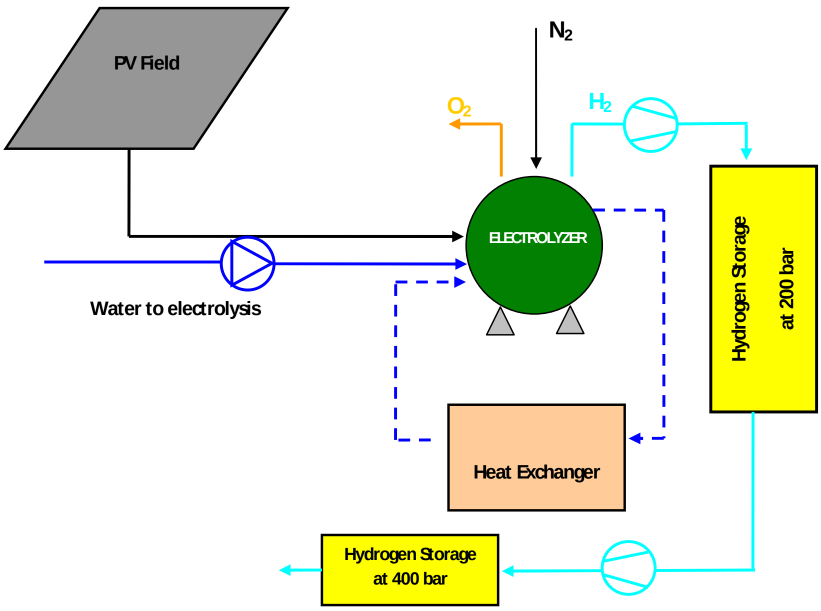

Figure 2. Hydrogen Refueling Station lay-out

Energetic Analysis

In this part, an energetic analysis of system is done using a Matlab® Simulink® tool called ESSFER [4] developed by Termotecnia Group of University of Seville. In Figure 3, a picture of block models connected in Simulink is shown.

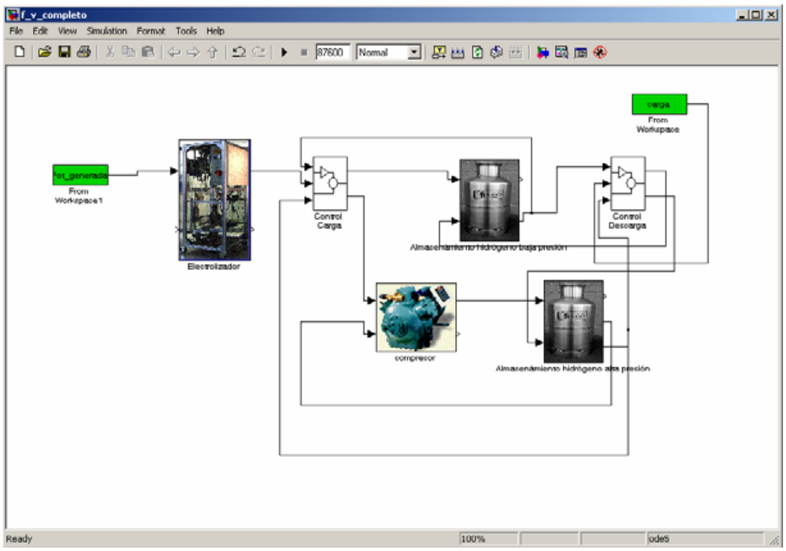

Figure 3. Refueling Station in Simulink using ESSFER blocks.

Taking into account solar radiation in installation site (Sanlúcar la Mayor), and photovoltaic system models described in [5] and [6], electric power produced by photovoltaic field during a standard climatic year can be estimated. Profile of electric power can be shown in Figure 4.

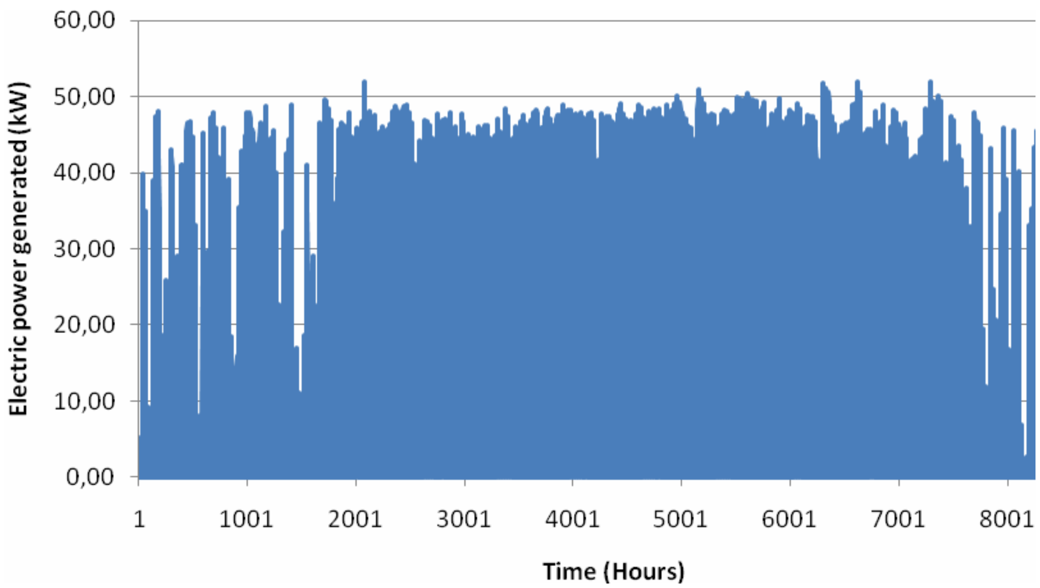

Figure 4. Electric Power Generated by Photovoltaic panels (kW)

Hydrogen generated by electrolyzer can be calculated using mathematical models that appears in reference [4] and [7]. Hydrogen consumption is estimated in 6 kg every working day (during a year), with steps of 2 kg at 10 a.m., 2 p.m. and 6 p.m. This step consumption is the vehicle hydrogen load developed also in project Hercules.

Next, system operation is explained:

- Electrolyzer takes electric energy from photovoltaic (PV) field and produces hydrogen that is stored in high-pressure vessel (200 bar).
- When high-pressured vessel reaches it maximum hydrogen level, electrolyzer is shut down, also if PV field is producing electric power.
- Dispenser takes hydrogen from high-pressure vessel, compress it, and serve it to hydrogen vehicle. If high-pressure vessel is at it minimum hydrogen level, dispenser cannot take hydrogen from the vessel, and at the moment of car refueling, hydrogen cannot be supplied to vehicle.

With electric power generated, system operation, and characteristic of all system components, installation can be simulated.

Table 1 shows a summary of simulation results concentrated in months.

Also, taking into account PV field electric energy produced and consumed by electrolyzer and system operation, total use of electric energy produced by PV field to produce hydrogen is shown in Table 2 (results are concentrated in months).

	PV Field Electric Energy Produced (kWh)	Electrolyzer Electric Energy Consumed (kWh)	Compressor Electric Energy Consumed (kWh)	Dispenser Electric Energy Consumed (kWh)	H_2 produced (kg)	H_2 consumed (kg)	H_2 requested (kg)
January	4937,65	4937,65	1042,92	267,14	83,37	76,00	186,00
February	6827,29	6827,29	708,72	194,91	115,27	110,00	168,00
March	8006,31	8006,31	999,23	185,99	135,12	126,00	186,00
April	12396,16	10759,09	2395,85	60,62	181,24	180,00	180,00
May	11848,04	10885,30	2089,86	88,00	183,60	180,00	186,00
June	15075,28	10612,03	3121,19	46,90	178,62	180,00	180,00
July	15456,42	10934,48	3210,13	47,48	183,94	186,00	186,00
August	14750,46	10977,45	3055,73	47,72	184,62	186,00	186,00
September	11770,06	10336,55	2333,58	55,92	174,03	180,00	180,00
October	10276,66	10169,39	1498,02	129,46	171,30	172,00	186,00
November	5947,63	5947,63	601,38	228,14	100,46	96,00	180,00
December	3983,79	3983,79	377,30	255,71	67,35	60,00	186,00

Table 1. Simulation Results concentred in months.

	PV field Use to produce hydrogen (%)
January	100
February	100
March	100
April	87
May	92
June	70
July	71
August	74
September	88
October	99
November	100
December	100

Table 2. PV field use to produce hydrogen (%).

Simulation result comments

Next, several comments are done about simulation results:

- Total electric energy produced by PV field is 121,275 MWh and total electric energy consumed by electrolyzer is 104,376 MWh, so average use of PV field by electrolyzer is 86%.

- In Figure 5, pressure variation in hydrogen vessel is represented. As it shown, there are many hours where hydrogen vessel is at its minimum level and at its maximum level. Maximum level is reached commonly in summer time, when irradiation is higher and energy electric production is higher. Otherwise minimum level is reached in winter times when solar irradiation is lower.

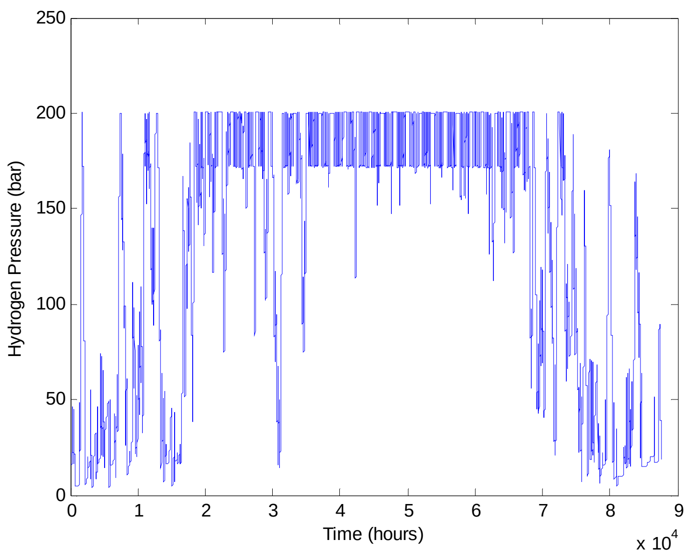

Figure 5. Pressure variation in Hydrogen storage tank.

- Compressor and dispenser electric energy consumption is about 20% of chemist energy of hydrogen produced.

Conclusions

In this article, a hydrogen refueling station sited in Seville province has been described, analyzed and simulated using Matlab® Simulink® software. Most important conclusions are:

- There are several hours during typical climatic year where hydrogen storage tank is at its minimum level, so hydrogen cannot be supplied to vehicle in fuel station. Also, exists many hours (mostly in summer time) where hydrogen vessel is at its maximum level, so electrolyzer must be disconnected from PV field. These two problems can be solved with a higher storage system.

- First objective, supply hydrogen to car is guaranteed because hydrogen consumption estimation, based on car uses, has been higher than real.
- Simulation results will be compared with real data's taken from refueling station with it will be operative (early 2009).

References

[1] http://www.fuelcells.org/info/charts/h2fuelingstations.pdf

[2] http://www.solarpaces.org/Tasks/Task1/PS10.HTM

[3] Maria del Mar Arxer, Luis E. Martínez Calleja, "Hercules project: Contributing to the development of the hydrogen infrastructure", Volume 171, Issue 1, Pages 224-227.

[4] F.J. Pino, F. Rosa, "Desarrollo de una herramienta de simulación basada en energía renovables y tecnología del hidrógeno", Energía. Vol. 32. Núm. 190. 2006. Pag. 80-87.

[5] A. Braunstein and J. Appelbaum, "Determination of solar cell equation parameters from empirical data". Energy Conver 17 (1977), pp. 1–6

[6] E. Bilgen, "Solar hydrogen from photovoltaic-electrolyzer systems", Energy Conversion and Management, Volume 42, Issue 9, June 2001, Pages 1047-1057.

[7] O. Ulleberg, “MODELING OF ADVANCED ALKALINE ELECTROLYZER- A SYSTEM SIMULATION APPROACH”, International Journal of Hydrogen Energy, Volume 28, Issue 1, January 2003, Pages 21-33.

View publication stats