Study of Hydrogen Production from Wind Power in Algeria

L. Aiche-Hamane, M. Belhamel, B. Benyoucef, M. Hamane

This document appeared in

Detlef Stolten, Thomas Grube (Eds.):
18th World Hydrogen Energy Conference 2010 - WHEC 2010
Parallel Sessions Book 3: Hydrogen Production Technologies - Part 2
Proceedings of the WHEC, May 16.-21. 2010, Essen
Schriften des Forschungszentrums Jülich / Energy & Environment, Vol. 78-3
Institute of Energy Research - Fuel Cells (IEF-3)
Forschungszentrum Jülich GmbH, Zentralbibliothek, Verlag, 2010
ISBN: 978-3-89336-653-8

Study of Hydrogen Production from Wind Power in Algeria

Lilia Aiche-Hamane, **Maiouf Belhamel**, **Boumedienne Benyoucef**, **Mustapha Hamane**, Centre for Development of Renewable Energies (CDER), BP62 Route de l'observatoire. Bouzaréah. 16040Alger, Algeria

Abstract

An overview of the potentiality of hydrogen production from wind power in Algeria has been given in this study. Wind resource assessment has been presented in cartographic form and windy sites have been identified for wind power application.

A system constituted by a wind turbine, an electrolyser and a power conditioning device have been proposed for the study of hydrogen production in the southwest region of Algeria.

For this purpose, the transient system simulation program (TRNSYS) have been used. The results obtained showed the sensitivity of hydrogen production to the wind resource trend and the importance of optimisation of the electrolyser according to the power produced by the wind turbine.

1 Introduction

Nowadays, wind energy is the fastest growing renewable energy sector in the world with annual growth of 29% in 2008[1] which represents 1.5 % of the global electricity consumption. Nevertheless, the instability caused by the wind turbines to the grid and the intermittence of the wind source, make necessary to develop efficient energy storage system.

Hydrogen as an energy vector, together with electrolyser and fuel cell technologies can provide a technical solution to this challenge. Additionally, the use of hydrogen for a clean transportation fuel will increase the need of renewable hydrogen generating.

However, one of the inherent drawbacks of wind power is that the wind velocity is highly intermittent, on a second by second basis, as well as hourly, daily, and even seasonally.

This inconvenient makes necessary to study the feasibility of wind-hydrogen systems according to the wind resource in order to choose the adequate wind turbine and electrolyser components at site installation [2].

The aim of this study is to provide necessary information for future use of wind power for hydrogen production in Algeria.

In the present work, a wind power hydrogen system is proposed. This system consists of wind turbine, AC/DC converter, electrolyser and hydrogen storage tanks.

The results obtained for regions situated in Algeria are presented in order to evaluate the viability of electrolytic hydrogen wind production systems.

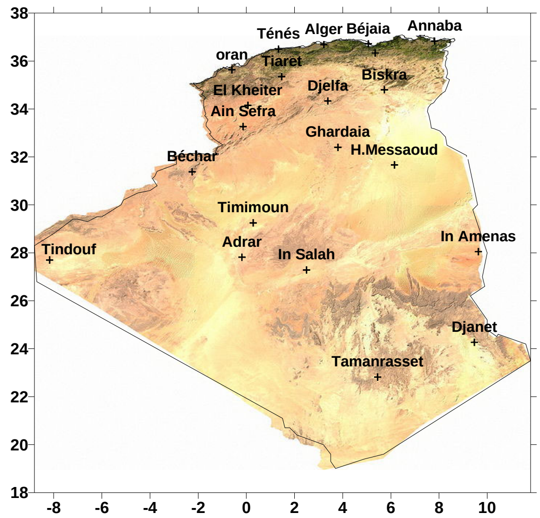

Figure 1: Geographical Topography of Algeria.

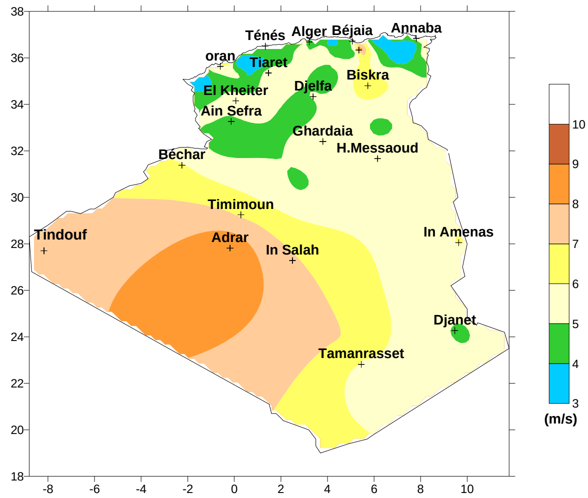

Figure 2: Annual wind speed distribution over Algeria at 50 m height.

2 Wind Energy Potential

Algeria is the second largest country in Africa and the first one in the Mediterranean region with 2.381.741 Km^2, located in the northern part sharing a vast coastline of about 1200 km along the Mediterranean Sea, with over four-fifths of its territory covered by the Sahara desert.

A study of the wind resource in Algeria has been carried out using wind data of 75 meteorological stations for a period of 11 years at 10 m height measurement [4].

The annual wind speed distribution at 50 m height plotted in Fig.2 indicates that the wind resource is very promising in Algeria. Areas that are potentially suitable for wind energy applications are dispersed throughout much of Algeria, particularly in the Sahara where the wind resource is more important on the whole area.

In the southwest including Béchar Timimoun, and Tamanrasset, the wind speed is greater than 6 m/s exceeds 7 m/s over Tindouf and In Salah and reaches 8 m/s throughout the big region of Adrar.

3 Hydrogen Production from Wind Power

A promising option for clean hydrogen production from wind power is electrolysis.

Electrolysis uses direct current (DC) electricity to split water into its basic elements of hydrogen and oxygen. Since this process uses only water as a source, it can produce up to 99.9995 % pure hydrogen and oxygen.

There are three principal types of water electrolyser: alkaline (referring to the nature of its liquid electrolyte), proton-exchange membrane (referring to its solid polymeric electrolyte), and solid-oxide (referring to its solid ceramic electrolyte). The alkaline and PEM electrolysers are well proven devices with thousands of units in operation, while the solid-oxide electrolyser is as yet unproven. The PEM electrolyser is particularly well suited to highly distributed applications. The alkaline electrolyser currently dominates global production of electrolytic hydrogen.

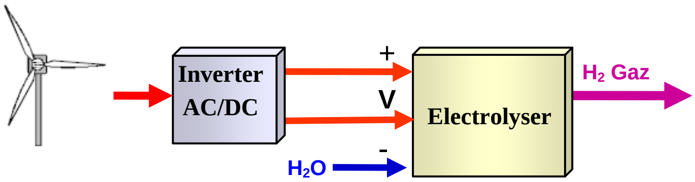

Figure 3: Wind hydrogen system production.

A system of hydrogen production from wind power has been proposed in this study. It consists of a wind turbine, an AC/DC converter and an alkaline electrolyser (fig.3). In this system, the AC output of the wind turbine is converted to a DC voltage suitable for electrolyser operation through an AC/DC converter.

The simulation of this system has been done using Hydrogems library developed by Ulleberg [7] and integrated in the transient system simulation program (TRNSYS) [8]. The simulation models for the wind turbine, AC/DC converter and electrolyser used have been tested and verified against measured data from the reference plant [7].

The wind turbine selected is of the type Nordex N54 which starts the power production at 4m/s and reaches the maximum rated output power of 1 MW at 14m/s at 70m hub height tower. A representation of the power output from the wind turbine as a function of wind speed is shown in fig.4.

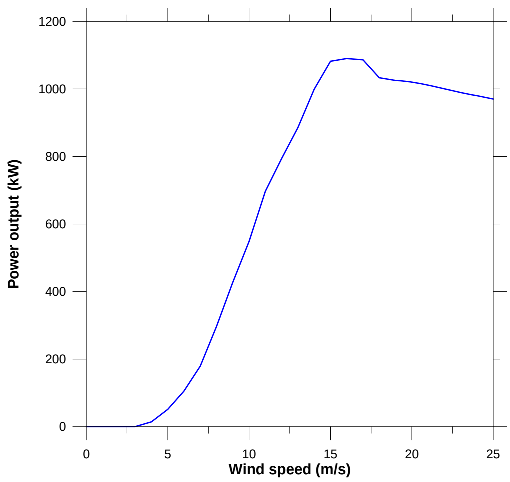

Figure 4: Power curve of the NordexN54 wind turbine.

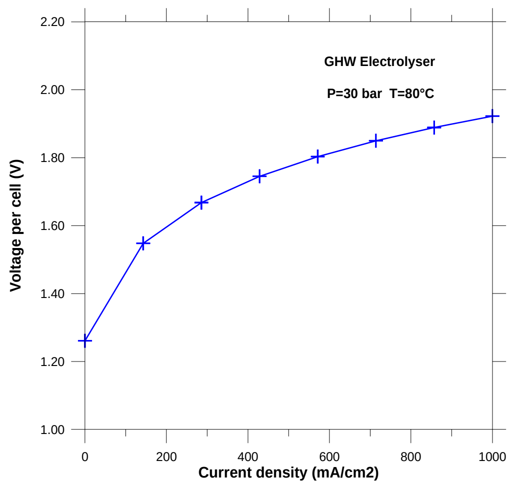

Figure 5: Voltage-current characteristics of the GHW electrolyser.

The characteristics of GHW alkaline electrolyser operating at 30 bars with a nominal temperature of 80°C were considered. The number of cells has been fixed to 200 cells in order to increase the power input of the electrolyser. The voltage-current curve of the GHW electrolyser used in the simulation is presented in fig.5.

4 Results and Discussion

The TRNSYS model has been used to simulate the hydrogen system production at six sites situated in the south west desert of Algeria. Wind speed data of these sites measured at 10m height have been used for the simulation. The annual rate production of hydrogen has been obtained and plotted in fig.6.

It appears clearly that hydrogen production is highest at Adrar because of its high wind speed while the lowest production is confirmed for Hassi Messaoud and Béchar. These results are obvious since hydrogen production depends on the power input in the electrolyser which is fed by the wind turbine.

It can be also noticed that hydrogen production is seven times greater in Adrar where the mean wind speed is 6 m/s than Béchar with 3.7 m/s mean wind speed. Thus, efficiency of wind hydrogen system production strongly depends on wind resource available at place.

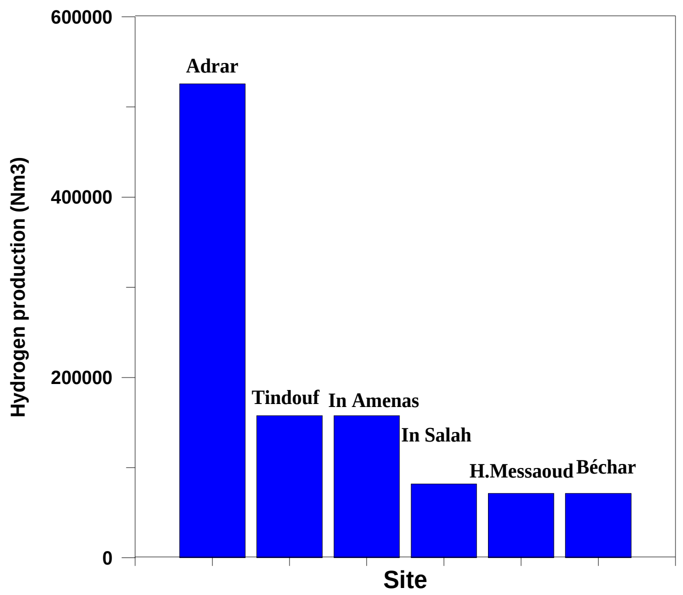

Figure.6: Annual hydrogen production from 1 MW wind turbine.

5 Conclusion

The purpose of this study is to give an overview of the feasibility development of wind-hydrogen systems in Algeria. The wind resource assessment has shown the big potentiality of wind power production in Algeria.

Furthermore, this contribution gives a simplified methodology to evaluate the potential viability of electrolytic hydrogen wind production systems.

In order to increase the efficiency of the wind-electrolyser system, it is primordial to optimise the wind turbine according to the wind potential available at site installation and choose than the right electrolyser according to the wind power produced.

The present study must be improved in future works by a techno-economic optimisation that takes into account the sizing and the cost of the different components of the system.

References

[1] World Wind Energy Association, Press Release, available on: www.wwindea.org , 2010.

[2] L.Aiche-Hamane, M.Belhamel, B.Benyoucef, M.Hamane,"Feasibility study of hydrogen production from wind power in the region of Ghardaia", International journal of hydrogen Energy 2009,34, 4947-4952.

[3] Available on: www.desertec.org, 2010.

[4] L. Aiche-Hamane L. "Contribution à l'élaboration de la carte du gisement énergétique éolien de l'Algérie". Mémoire de magister, institut de mécanique, université Saad Dahleb de Blida, Algérie, 2003.

[5] L.Aiche-Hamane, M.Belhamel, M.Hamane, 2008, "Estimation of hydrogen production from wind power in the south of Algeria", International Scientific Journal for Alternative Energy and Ecology ISJAEE, No. 5 (55), p 21-25.

[6] Available on: www.windpowermonthly.com/news/982260/Algeria-seals-deal-first-ever-wind-farm, 2010].

[7] O.Ulleberg, 1998, Stand-Alone Power Systems for the Future: Optimal Design, Operation & Control of Solar-Hydrogen Energy Systems. PhD thesis, Norwegian University of Science and Technology, Trondheim.

[8] SA Klein, WA Beckman, JW Mitchell et al, 2007, "TRNSYS—a transient system simulation program", Solar Energy Laboratory, University of Wisconsin, Madison.

[9] O. Ulleberg, 2003, "Modeling of advanced alkaline electrolysers: a system simulation approach", International Journal of Hydrogen Energy, Vol.28, pp. 21-33.