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Assessment of solar and wind energy as motive for potential hydrogen production of Algeria country; development a methodology for uses hydrogen-based fuel cells

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ABSTRACT

This study is based on method of storing the part of renewable energy in the hydrogen form for using in a fuel cell at the absence of solar radiation due to overcast day or in the night. In addition, the system advantage don't need a batteries compared with other systems. The present work is compared energy potential of the wind and solar with the results of hydrogen production and to address the various obstacles to study and evaluation. This work is assessment the renewable resources in various sites of Algeria, especially in Adrar area which is one regions of the high solar energy in the world, where the radiation rates exceed more than 2300 kWh/m^2 per year, the area is also characterized by high wind power. In fact, by these two energy sources (solar and wind) that it characterized by Adrar, it's interesting to combine electrical producing energy and hydrogen production. The studies indicate that there are the meteorological factors related to the nature of site (irradiation, temperature and wind speed) are linked to the generation of electricity by renewable energy. The results obtained showing that the hydrogen production related to the solar radiation values, where southern of Algeria has more hydrogen potential compared with the northern. The simulation results show that the energy supplied by a photovoltaic module type UDTS 50 can supply energy for ten electrolyzer cells which are connected in series with this module.

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Nomenclature

G	Solar radiation on a horizontal surface, Wh/m^2
I_{sc}	Solar constant, W/m^2
E_0	Eccentricity correction factor of the earth's orbit
ω_s	Sunset hour angle (°)
LAT	Latitude (°)
δ	Solar declination (°)
$f(v)$	Weibull probability density function
k	The dimensionless shape factor
c	The scale factor (m/s)
v	The average wind speed (m/s)
$V(t)$	The wind profile (m/s)
t	Time (s)
I_{ph}	The current generated by irradiance (A)
I_D	The current of diode (A)
I_s	The cell reveres saturation current (A)
I_p	The current of parallel resistor (A)
R_s	Series resistance of the PV cell (Ω)
R_{SH}	Shunt resistance of the PV cell (Ω)
I_{pv}	The current of PV module (A)
V	PV voltage (V)
K	Boltzmann constant $(m^2.\,kg.s^{-2}.K^{-1})$
T	The temperature of the cells (k)
N_s	The number of PV cells in series
N_p	The number of PV cells in parallel
q	The electron charge (j)
γ	The p-n junction ideality factor
I_{sc}	Short circuit current (A)
k_i	The short circuit current coefficient
T_r	The cell reference temperature (°C)
I_{rr}	The reverse saturation current at reference temperature (°C)
E_G	The energy of the band gap of the cells (j)
U_{elec}	The electrolyser voltage (V)
$E_{rév}$	Reversible voltage (V)
F	Faraday constant ($F = 96487\ C/mol$)
R	Constant of ideal gas ($R = 8.31\ j/mol.K$)
P_{0H_2}	Partial pressure of hydrogen (atm)
P_{0O_2}	Partial pressure of oxygen (atm)
β	Constant coefficient
I_{lim}	Diffusion limit current (A)
α	Transfer coefficient
I_0	Exchange current, (A)
C_{H_2}	Hydrogen concentration (M)
C_{O_2}	Oxygen concentration, (M)
Q_{H_2}	Quantity of hydrogen produced (m^3)
Q_{O_2}	Quantity of oxygen produced (m^3)
r	Ohmic resistance of the membrane (Ω)
D_{H_2}	Diffusion coefficient of hydrogen (m^2/s)
D_{O_2}	Diffusion coefficient of oxygen (m^2/s)
δ_0	Thickness of the diffusion layer (m)
A	Cell active area of membrane (m^2)
c_{mem}	The concentration in the membrane (M)
l_m	Membrane thickness (m)
λ_m	Hydration ration
Q	The exchange capacity of membrane (M)
ΔH	Change in enthalpy of a reaction (j)
ΔG	Change Gibbs free energy of reaction (j)
ΔS	Change in entropy of a reaction (j)
Kab (1)	kabertene (Wind) is power station by wind energy
Kab (2)	kaberten (PV) is power station by PV energy
SKTM	is a joint-stock company with a capital subscribed in full by Sonelgaz and whose head office is located in Ghardaia of Algeria

Introduction

Hydrogen is one of materials appropriate storage for use in the production of energy without loss, whatever the storage period. The energy future based on renewable energy, whereas storage of energy is the problem posed in today; this study has been proposed as a solution to store the part of renewable energy from solar-hydrogen for use afterwards. In the present work, study of solar photovoltaic systems coupled with electrolyzer for storage renewable energy in the hydrogen form and clarifies some of the factors affecting this technique. Several authors have studied about this subject where described their studies as follows: Simone Pascuzzi et al. [1] are studied the performance and the real energy efficiency of the electrolyzer analyzing its operational data collected under different operating conditions affected by the changeable solar energy that characterizes the site where the experimental plant was located, it has been concluded that the performance of the electrolyzer could be improved by changing the arrangement of the batteries bank, so the electrolyzer could be alternatively charged by fuel cell or by PV modules. Xiong et al. [2] studied the modeling and experimental validation system fuel cell/battery for management and control the power, this study is showed the power DC/DC converters, including unidirectional and bidirectional by utilized (TDC) to application the power management for system, duplex mode of operation of the DC/DC converter was automatically enabled by a managing of power with (SOC). R. Valdés et al. [3] they optimized and design the hydrogen production plants with storage reserves of photovoltaic power system. James D. Maclay et al. [4] have studied the hybrid energy storage systems coupled to photovoltaic generation in residential applications, the study showed the technical feasibility of operating such as system under the simultaneous dynamics of solar input and load. In recently concentrated solar technology an economic technique was studied to produce hydrogen, this work presented the study of hydrogen production using hybrid solar parabolic trough-gas power plant-electrolysis system to determine the effect of the climatic conditions on the cost of hydrogen production, it has been studied two different sites of Algeria country (Annaba in Northern and Adrar in Southern) [5], also by same author is studied a comparative economic competitiveness assessment of hydrogen as a fuel in the transport sector in Algeria, in this work, the competitiveness of the hydrogen based fuel with gasoline fuel has been addressed [6]. Simone Pascuzzi et al. [7] analyzed the main safety aspects of this power system