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# Hydrogen Production Assessment for Algeria Energy from Water

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**Abstract.** In the present work, solar radiation and the meteorological data are reviewed; a system photovoltaic-electrolysis for hydrogen production is proposed and presented. An estimation of solar hydrogen potential is carried out in the site of the Unit of Applied Research in Renewable Energy (URAER) Ghardaia, Algeria. This estimation is based on real data taken on site. The estimation of the production potential is based on the different systems efficiencies and annual average for the last ten years of the daily global radiation on horizontal plan. It is an evaluation of hydrogen production by square meter photovoltaic panel and per day.

The assessment results of the annual, monthly and seasonal solar hydrogen potential production in Algeria show that the potential is significant by taking account of the intensity of the insolation and the water resources. The use of hot water of the albian will increase hydrogen production rate. This paper will explore the results of this work in detail.

**Keywords:** Hydrogen production, solar radiation, evaluation.

## 1. Introduction

Energy is an essential element in human life. A secure, sufficient and accessible supply of energy is very crucial for the sustainability of modern societies. The demand for the provision of energy is increasing worldwide and will continue to rise as developing nations reach developed status and developed nations maintain their modernization trends.

In order to deal with the future energy challenges and to make the long-term energy supplies more secure, significant diversity needs to be introduced into the energy supplies. Solar generated electricity, one of the most promising form of renewable energy, could provide one possible and significant step in this direction, since the technology is developing all the time, and there are suitable locations for its large-scale generation. However, the diversity of supply does not depend only on the diversity of the source, and its exploitation, but also on the diversity of the transportation. Solar generated electricity can be transported as electricity, needing high voltage supply lines, or as hydrogen, thus needing suitable pipelines which are available in the southern Algeria.

Southern Algeria includes the desert and arid areas of the Sahara. This Sahara occupies more than 85% of the own territory, it is characterize by the most extreme climatic conditions. Intense insolation, quantity sufficient of water (albian), vast spaces for solar energy installation and even the existence of pipelines for the evacuation of solar hydrogen produced.

## 2. Climate of Algeria

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A Mediterranean climate covers North of Algeria, while a desert climate reigns on the South During the summer, the hottest months are July and August. The North is situated on the coastal cities, the winter temperatures vary between 8 and 15 ℃. It climb with 25 ℃ in May to reach an average of 35 ℃ in July and August. In the center, in the mountains of Kabylie and of Aurès like in the highlands of Djelfa, the temperature borders the 5 ℃ even -7 ℃ in winter. Snow is frequent there in winter. The summer temperature varies from 35 ℃ with 40 ℃. As for the South, in the Sahara, the temperature is 15 to 28 ℃ in winter, to reach 40 to 45 ℃, even more in summer [1]. We present in Table 1 different data concerning for studying sites [1]:

Table 1: Data for different studying sites maintaining the integrity of the specifications

| Sites | Latitude | Longitude | Average elevation (meters) |
|---|---|---|---|
| Adrar (01) | 27°49'N | 0°11'w | 264 |
| Algiers (16) | 36°43' N | 3°15'E | 25 |
| Djelfa (17) | 34°41'N | 3°15'E | 1144 |
| Saida (20) | 34°52' N | 0°9' E | 750 |
| Oran (31) | 35°54'N | 0°53'w | 112 |
| Illizi (33) | 26°30'N | 8°26'E | 754 |
| Tindouf (37) | 27°40'N | 8°08'w | 402 |
| El oued (39) | 33°22' N | 6°53'E | 183 |
| Ghardaia (47) | 32°36'N | 3°81'E | 547 |

In Fig. 1 we presented on the hand the sites studied in our paper and in another hand we show the deposit of the geothermal resources which is called the Albian, the detrital formations of the continental guide constitute a large tank covers a surface of 600.000 km$^2$. In Algeria it is localised in the northern part of the Sahara, this tank levels in the south, it is semi free in the west and captive in its Eastern part [2].

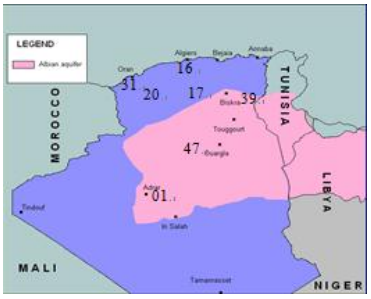


Fig. 1: The Algerian map and the extension of the Albienne nappe

## 3. Solar Potentiel in the South of Algeria

The Algerian Sahara constitutes one of the most significant solar insolation in the world. With a clear sky, almost without nebulosity, the Sahara is the area of the sun. The duration of insolation, about 3500 hours/year is most significant in the world. It is always higher than 8 hours/day except for the extreme south where it goes down up to 6 hours/day during the summer, so it can reach until more than 12 hours/day in the center of the Sahara. Of share its geographical position, the duration of daily insolation does not present significant differences between the different months of the year, as it is the case of northern cities. This allows an equal availability during all the year. The annual solar radiation received is about 2650 kWh/m2 [3]. The daily power received is always higher than 5kWh/m2 and can reach easily 7kWh/m2. Ghardaïa represents a significant part of the Algerian Sahara, if all this energy is developed, that would constitute a source of very significant energy. In Table 2, it can be seen monthly averaged insolation incident on horizontal surface (kWh/m2/day) in URAER situated in Ghardaia southern Algeria as follows [4]:

## 4. Estimation of Hydrogen Production

Several techniques exist for hydrogen production. It is done by gas resources because the majority of produced hydrogen, particularly for petrochemical industry is obtained starting from natural gas particularly

by steam reforming [4], [5]. Hydrogen can be also produced using renewable resources by the use of solar energy for water dissociation, the combination of photovoltaic module to supply an electrolyser which dissociate water molecule to oxygen and hydrogen [6]-[8]. This system is made up primarily:

A solar installation (photovoltaic modules) for electrical energy production, the efficiency depends on the nature of cells and the weather conditions. The efficiency can reach 12% [9] but it was improved theoretically it reach 17% [10]. Water used at elevated temperature leads to a rise the system efficiency [11], which shows the effciency of the use of hot water resulting on the one hand from the albian shown in the Fig. 1, and on the other hand of the recovered hot water of the loop of thermal photovoltaic module (cogeneration) [10]. A system of battery for energy storage with efficiency of 85%. The electrolyzer which includes an assembly of several Proton Exchange Membrane (PEM) (dimensioning) and which ends in two electrodes. The electrolytic solution is mainly water. The electrolytic system efficiency depends as well on the nature of the cell (85 %) and its operating temperature [12].

Table 2: Monthly averaged insolation incident on a horizontal surface (kwh/m$^2$/day)

| **Lat** **Lon** | **32.36** **3.81** | **Jan** 2.50 | **Feb** 3.79 | **Mar** 5.16 | **Apr** 6.68 |
|---|---|---|---|---|---|
| Jun 7.36 | | Jul 7.74 | Aug 7.12 | Sep 5.88 | Oct 4.05 |

## 5. Results and Discussion

Results show hydrogen production assessment while basing on the output of the various systems and the annual averages over the ten last years of solar radiation on the horizontal surface. It is expressed per square meter of photovoltaic module per day [6]. These results show that hydrogen potential is very significant through southern Algerian.

In order to determine the seasonal production and the regional effects, we compared the production rate as well as the monthly distribution in twelve sites. Fig. 2 (a) show hydrogen production rate according to the month [6]. It can be seen that hydrogen produced in August is twice more significant than in December or in January. It can be seen, that the production is practically the same for July in the whole sites, this is not the case for the other months when it is definitely higher than the center of the Sahara and especially than Ghardaïa. We compared the seasonal production. Fig. 2 (b) shows the seasonal production for each site.

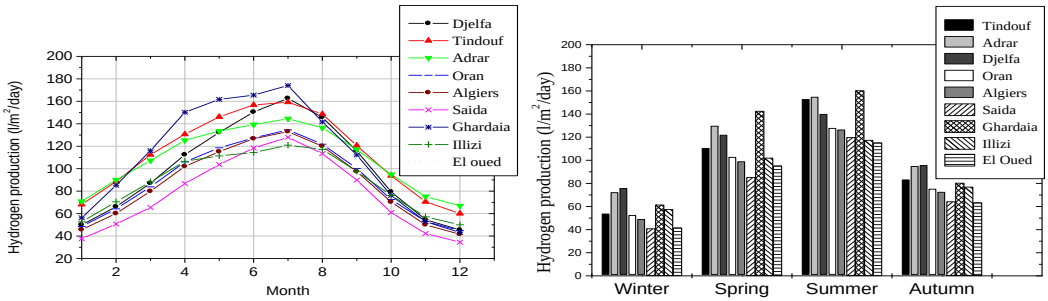


Fig. 2: (a) Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m$^2$/day); (b) Seasonal evaluation of solar hydrogen production in Different Algerian sites [6]

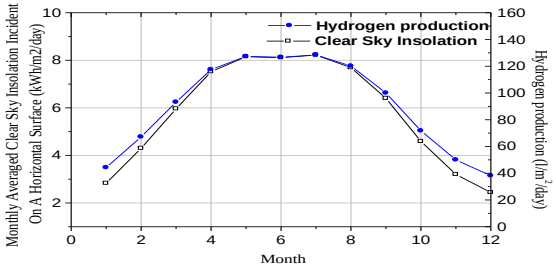


Fig. 3: Hydrogen production in Gharda ïa (southern Algeria) [6]

We can also see that spring and the summer are the seasons of the most significant hydrogen production. The city of Ghardaïa and especially the site of the unit of applied research in renewable energies is the site which represents the most significant potential for hydrogen production among the sites selected, as it can be seen in Fig. 3, the quantity of hydrogen produces for a monthly average incident insolation of clear day of the year reach 130 l/m$^2$ PV/day when solar radiation is 8.2 kWh/m$^2$/day [6].

## 6. Conclusion

Hydrogen production potential using photovoltaic system and electrolyser was evaluated. The results show that the potential is significant. Results identify the most promising site which is Ghardaia (Southern Algeria) situated at the Unit of Applied Research in Renewable Energy. We also used average data to highlight with precision the seasonal variations. The use of the hot water of the Albian water will increase the efficiency.

Hydrogen production in Algerian Sahara and precisely in Ghardaïa represents a very important green energy which could be used not only on scale national but on scale and this while transporting hydrogen in pipelines which transport natural gas towards the foreigner.

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