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Viability of solar or wind for water pumping systems in the Algerian Sahara regions – case study Adrar

B. Bouzidi*

Center of development of Renewable Energies, BP 62 Bouzaréah, Algeria

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ABSTRACT

The availability of water and the ability to access are the key questions arising in developing countries including Algeria. Indeed, due to lack of electricity, the Saharan regions representing 80% of the country are facing major problems to cover drinking water needs. Paradoxically, there is in some of these areas an important quantity of groundwater at shallow depths. On the other hand, Algeria has considerable renewable energy resources, particularly solar and wind energy options that are now relevant solutions to this problem. To date, few facilities specifically photovoltaic were conducted throughout the national territory (Saharan regions and highlands). However vandalism (destruction, robbery, etc.) did not spare these facilities particularly in border areas, such Adrar, and therefore prospective purchasers of such systems are discouraged. A new strategy to deal these actions became necessary for the regions most affected.

In this context, we propose to study and compare the two options for solar and wind water pumping applications in the Adrar region. Because it has become necessary that the energy issue arises in new terms. It is proposed now to ask, taking into account the circumstances, which form of energy would be appropriate for what and for which ends. In other words, we will essentially develop a new spirit, a new attitude that would be based on a determination on a case by case basis, of the appropriate energy resource. This will allow to have another vision of the use and the viability of renewable energies.

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* Tel.: +213 21901503; fax: +213 21901654.
E-mail address: bouzidibelkacem@yahoo.fr

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1. Introduction

The water availability and the ability to access to it are the key issues facing the community in the world especially in developing countries. Algeria's Saharan regions which cover more than 80% of its area (2,381,741 km^2), is also affected and suffers more from this thorny problem. Needs for domestic water supply, irrigation of crops and watering of animals increase with population growth. In the absence of surface water, groundwater aquifers seems to be the only alternative to this dilemma, but is difficult for manual pumping and animals. However, preservation of ecosystems in the Saharan regions can be achieved with the fixing of the population in their areas by means of improving and developing their standard of living and so curb a little the exodus to the urban centers. This socio-economic development of these regions is closely related to two main factors which are the presence of water and energy availability.

Mechanized water pumping has become the only reliable alternative to lift water at a certain depth. Diesel and gasoline have traditionally been used to pump water in these regions. Their use requires a large volume of fuel when available. Using this type of system cause the discharge gases to the atmosphere, increases the level of pollution and nuisance to the environment and also pollution of groundwater and soil by fuel and lubricants.

On the other hand, renewable energy can provide alternative energy quite realistic due to their low environmental impact. Among the various identifiable sources of renewable energy in Algeria, two attract attention in this study for their important potential areas of applications: they are photovoltaic (PV) and wind energies [1–3].

The solar and wind water pumping systems are reliable, now emerging on the market and quickly become more attractive than conventional energy sources are particularly useful in remote locations where a regular fuel supply is problematic.

In the search for solutions to the energy management practices applicable to pumping irrigation schemes in the Sahara, it seems interesting to identify the most appropriate technology, taking into account the specificities of the region (solar or wind) and know the benefits of pumping technique based on the reliability of two renewable sources, namely solar photovoltaic and wind energy under certain conditions.

In the absence of surface water, groundwater is an important source for drinking and irrigation in these regions. In addition, the majority of these regions constituting the Sahara has an important groundwater resource, namely the Albian water which outcrops in some places. Fig. 1 shows the extent of the groundwater in Algeria, occupying the southeast and much of south-western Sahara.

Formations of continental clastic infill constitute a large reservoir of 600,000 km^2 [4]. In Algeria, it is located in the northern Sahara and extends to Tunisia and Libya. This reservoir is flush with the south it is semi free captive in the west and its eastern part [4,5].

In the absence of reliable means of drainage, renewable energies are the most appropriate solution to meet the energy needs of the population. However the acts of vandalism (robbery of PV modules) perpetrated in the isolated areas undermine the longevity and the use on large scale of these systems, more particularly the PV systems.

2. Potential energy of Adrar

Located in the southwest of Algeria (27°52′N, 0°17′W), Adrar occupies an area of 427,368 km^2, a population of 422,331 inhabitants (National Office of the Statistics-Algeria, 2010) with very low population density estimated at 0.98 inhabitants/km^2 (National Office of the Statistics-Algeria, 2010). Agriculture, traditional crafts as well as barter trade with neighboring countries (Mali, Niger), form the backbone of the economy of the region. Due to the very low standard of living, the majority of the population practices mainly subsistence farming. The rest of agricultural production is sold in the markets. The huge availability of groundwater at shallow depths in some places, easy to operate, means that agriculture could be developed on a large scale with moderate electrical power.

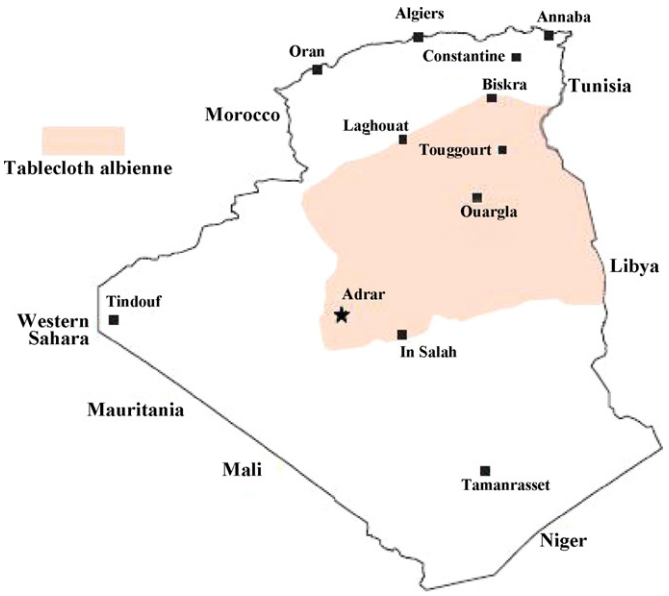

Fig. 1. The tablecloth albienne covers all Algerian central Sahara until Libya [4].

So the strengths of the Adrar region are mainly related to agricultural, phoeniculture (palm plantation) and other agricultural products, with the potential irrigable land is very important and the potential use of solar and wind according to the viability, and finally there is a huge aquifer of the groundwater.

The Adrar region has a pool solar and wind very significant. The operation of these inexhaustible energy resources can meet the energy needs of the population. The majority of villages in the wilaya (department) constituting Adrar could be considered as isolated sites due to the huge size and their distance from each other in addition to climatic conditions which are extremely difficult.

2.1. Solar energy

Algeria has a high solar potential and is adequate for the use of solar energy systems, particularly in southern regions (Sahara region). Based on data from the hourly global irradiation on horizontal surface, we can see from Fig. 2 that the Adrar region has a higher average annual daily to 5.7 kWh/m^2/day. Fig. 2 also shows the average monthly temperatures.

Fig. 2 shows that the winter has less solar potential whose average daily monthly global radiation varies between 3 kWh/m^2/day and 4 kWh/m^2/day. Solar radiation becomes very important between March and October when the average daily monthly global radiation varies from 5.5 kWh/m^2/day to 7.5 kWh/m^2/day. Fig. 3 shows the importance of global irradiation in terms of hourly PV array with a tilt angle equal to the latitude of Adrar relative to the hourly global irradiation on horizontal plane, where the values vary between 600 and 1000 Wh/m^2 for the month of January.

2.2. Wind energy

To assess the operating performance of a wind turbine at a given location, its energy production is first expressed in terms of wind speed. Among the many mathematical models used in studies of