INTEGRATION OF SOLAR ENERGY IN THE DEVELOPMENT OF PALMS IRRIGATION SYSTEM AND LONG-TERM BIO-ETHANOL PRODUCTION IN THE SOUTH OF ALGERIA

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Abstract- During the history, the economy of Ouargla city and surrounding (in south of Algeria) is based on date palms. These trees are very resistant to hot climate and their dates are rich in sucrose substance, so they are considered as promoter candidates for ethanol production. Promoting this potential necessarily involves cost reduction of agriculture palms; mainly the irrigation cost should be decreased. The application of a photovoltaic pumping system on medium well operating can achieve a payback period not exceeding at least 15 years even if grid extension cost is not included. The investigation by using Arcgis software shows that Ouargla basin has in important underground water sources with high flow rates and low depths. The wide flat area around this city allows huge agriculture expansion to develop a profitable bio-ethanol industry. In this work, ethanol extraction is limited to waste dates as row material. For 2013, the bio-ethanol extraction from only three date varieties (Ghers, Deglet-Nour and Deglet-Beida) is estimates about 23,500 liters, by using a trend model it can reach 148,500 and 648,500 liters in 2018 and 2038 respectively. The estimation by a voluntary model by taking into account an exploitation rate as 80% of reserved agriculture land, forecasting bio-ethanol production will be at least quadruple.

Keywords- Palm Trees, Solar Pumping, Date's Waste, Bio-Ethanol, Prospecting

I. INTRODUCTION

The date palm is one of the oldest cultivated fruit trees, where the earliest records show that Iraq's culture has been practiced for 3500 years BC. In desert environment, palm creates a micro-climate conducive to life and their wood can be used as construction materials. Palm fruit (date) is a bay consisting of a single seed, it is usually oval or spherical shape attached to the pedicels) by the perianths, it has varying colors depending on the cultivar and growing conditions. This fruit is considered not only a food base, but its poor quality is used as pet's food. In Algeria, many date species are slightly exploited except Deglet Nour, Ghers and Degla Beida. These rich sugar resources are important substrates to produce many substances such as ethanol. The bio-ethanol, as alternative source, is the most used vehicle fuel in the world and its promotion has significant ecological interests. Indeed, it burns more cleanly than gasoline or diesel.

In Pakistan, A. A. Noor et al. activated strains used them for ethanol fermentation from dates. Higher yield of ethanol was observed when the activated strain where inoculated in dates syrup as substrate at 120 rpm, having pH 4,5 at 30 °C at 600 nm after 72 h post incubation. In India, N. Gupta et al. evaluated various indigenous strains isolated from date palm sap for ethanol production. Isolate strain SCP-1 was found superior showing 12,5% ethanol production, high ADH enzyme activity (4,38 units/ml) and higher alcohol tolerance maintaining cell viability at 12% ethanol in YPD medium up to 48 h. In Gabes (Tunisa), B. Louhichi et al. studied the bio-ethanol production from three date's varieties (Kunta, Eguoua and Bouhatem). Their all tests showed ethanol production with a concentration around 25% (V/V), moreover the yeast used in the fermentation process is capable of producing alcohol even at a pH of 3.8. In Saudi Arabia, M. H. Gaily et al. examined ethanol production from date's extract. For obtaining 75 and 90% fructose in sugar, the respective losses in fructose exceeded 39 and 63% and the ethanol yield was at 63% of the theoretical one. In the same country, A. K. Sulieman et al. studied ethanol production from low-quality dates.

The average ethanol yield for all experiments was greater than 71% of its theoretical value. Fermentation at 30°C and 120 rpm gave ethanol yields of 91.3%, 68.7% and 54.8 % for the 10, 15 and 20% initial sugar concentrations, respectively. In Adrar (Algeria), A. Boulal et al. conducted many tests to optimize alcoholic fermentation of three date varieties (Hmira, Tinacer and Kaciene). The comparison of crude alcohol degree of dates showed that for the three varieties are respectively 22°, 19°and 18°. In El-Oued (Algeria) K. Oucif carried out experimental tests for three date species (Ghers, Bouchaira and Tenessine), they obtained for each specie the following rate of ethanol production: 1.560, 1.1875 and 0.605 ml/g respectively.

This work presents an overview on the development of ethanol industry using waste dates. This methodology focuses on the key factors leading to reducing cost of palms agriculture. In particular, irrigation requires the research for sustainable and cheaper power supply. Photovoltaic energy seems to be the most favorable

candidate to provide reasonable power for long period with short payback. So, bio-ethanol can reach competitive price in comparison to subsidized gasoline, provide a lot of jobs, keep the fossils resources and protect the environment.

II. PRODUCTION OF DATES

The present work is limited to studying only Ouargla region which is located in the south-eastern Algeria, at the bottom of a large synclinal basin. This region is characterized by sedimentary **fill in wide valley of Oued Mea**, and Ouargla city is positioned at Latitude 31° 57' 10"North and Longitude 5° 19' 54" East divided into six sub-areas: Ouargla center, Sidi Khouled, Hassi Benabdallah, Rouissat, Ain El-Beida and Ngoussa. In 2013, the total of palm trees in Wilaya (province) of Ouargla is 2 522 695 trees including 1 032 033 trees in O**uargla city and its neighboring**.

Figure 1 shows the distribution of areas, palms and dates production; we note that 78% of existing palms are productive. In Ouargla city center, dates production is high, but, in Hassi Benabdellah, it is small due to the wide new palm plantations. The wilaya of Ouargla has 21515 hectares of area planted by date palms including 9080 hectares in Ouargla region. This region gets an annual dates production of 523 10^3 quintals which is divided as 34% of Deglet Nour, 51% of Ghers, 0.1% of Degla Beida and 15 % of other varieties (this last date kind is not included in this study). Specific productivities of these palm species are respectively 61.8 kg/tree, 67.3 kg/tree and 42.3 kg/tree.

Low grad dates obtained from date's tri are non-consumable fruits and traditionally intended to livestock. They are composed by different categories, represented primarily by dried dates (H'chef) and unmated dates (Sich). Generally, according to the climate condition, this waste is stated between 10% - 25% of date production, in the calculation; we take an average value of 15%.

III. PRODUCTION OF ETHANOL

In this study, we opted to the wastes of date as row material to produce ethanol. In this production process, we choose three varieties of the most dominant dates (Ghers, Deglet Nour, Deglat Beida) in the region of Ouargla. After washing and cleaning the dates, some devices are used such as bioreactor for the fermentation and water bath **for stabilizing the temperature**, then, obtained date wine is distilled to extract ethanol. Basing on the characteristics of date species studied by K. Oussif those are big similarity to dates produced in Ouargla region: Ghers, Deglet Nour and Degla Beida. The date's tri according to fruit quality gives some groups having different losses in organic components between 60% and 40%. By choosing the mean value of losses (50%), ethanol production rates become 0.78, 0.60 and 0.30 ml/g for Ghers, Deglet Nour and Degla Beida respectively. For 2013, waste dates mass is evaluated at 66400 quintals which can give 23500 liters of ethanol.

Through the programs set up by the agriculture administration for the land distribution in order to develop palm cultivation, we can predict ethanol production according to palm trees number and the harvested mass of dates. During the period between 2012 and the beginning of 2014, the agriculture administration in the wilaya of Ouargla has allocated an area for palms agriculture up to 172000 hectares. In this study, we adopt a period of 5 years for palm tree to reach an acceptable date production, the number of palms of 2013 is regarded as a reference to calculate the average date production and the tree density for new areas is set at 100 palms per hectare. So, in 2018, we can calculate the supplementary palms number which reaches 17200 10^3 trees with annual date production about 9400 10^3 quintals. This mass gives 1400 10^3 quintals as waste and the extraction of ethanol can reaches 500 10^3 liters. So, for 2018, the total ethanol production became 523.5 10^3 liters. Noting that we have considered all land dedicated to palms is exploited. Actually, not all allocated land is fully exploited, the percentage can turn around 20%, and this is due to the weak attraction of investors to agriculture palm trees. In 2018, with the rate of 20%, the total ethanol production can reach 105 10^3 liters. In case of promoting this industry, an optimistic rate of 80% can be taken where the ethanol production will be so significant and it continues increasing over 25 years (see figure 2). Noting that a small ethanol quantity is extracted from Deglat Beida in these areas, but for others areas in Algeria like Touggourt the potential is very high.

IV. IRRIGATION OF PALMS

By using Google Earth on Ouargla region, the surfaces planted by palms are determined with plotting their contours. Then, these contours are exported to Arcgis software to present them as geo-referenced surfaces with their parameters. For developing date palm industry, water resources are so necessary, knowing that the region has a huge potential for underground water reserves (Phereatic and Albian). In Figure 3, the points of water wells provided by local water authorities are presented using Arcgis (except the sub-region of Hassi Benabdellah: lack of data).

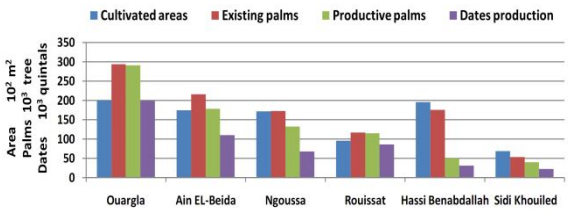


Fig. 1: Areas, palms and dates capacities

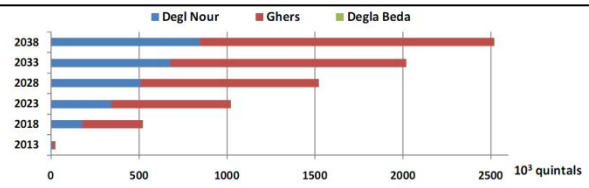


Fig. 2: Ethanol production at 80% of

The electrical energy used for pumping water is the main factor affecting palms expansion in Saharan regions. Although the huge water reserves which allow high exploitation, but pumping costs should be reduced. Figure 2 shows the power consumption by area, there is a high consumption in Ouargla center; this is due to large number of palm trees and wide irrigated area. Thus, this region has a significant date's production with high density. Also, noting that the exploration of some wells remains expensive for farmers whom sometime are unable to pay electricity bills, causing an important irrigation disruption in. So, for improving this situation, it is recommended to plan many new drilling for water wells beside those already existing in order to make easy their power supply by solar energy.

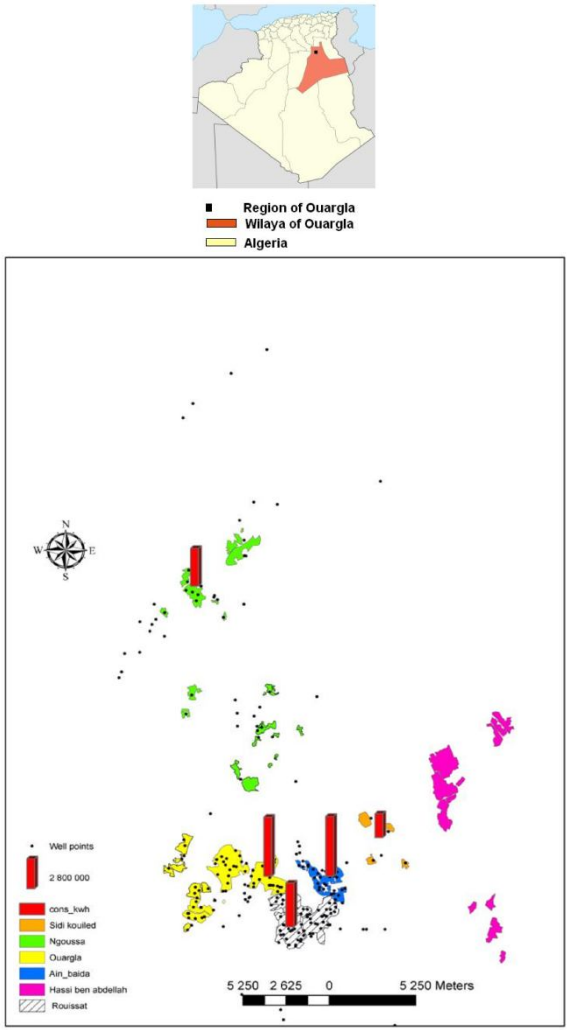


Fig. 3: Irrigation wells and electricity consumptions in Ouargla

V. SOLAR WATER PUMPING

Solar energy is available in abundance on the Earth's surface, but the flux received at the ground depends on several parameters such as orientation and tilt of the surface, latitude, pollution degree, altitude and receiving time. Among the solar systems, photovoltaic (PV) is recommended. During the absence of sunshine, PV systems are assisted either by connecting to the network which usually requires network expansion, or by autonomous systems such as wind, biomass, batteries, diesel generator and tank storing water. While moving towards a policy of intensifying well drilling which leads to sufficient irrigation during sunshine period and small water amount will be stored, so the latter system is very adaptable to our needs.

By knowing electrical energy needs and daily incident irradiation on PV generator surface, the generator pick power P_{cc} is expressed as follows:

$$\mathbf{P_{cc}} = \frac{\mathbf{G}}{\mathbf{F_m[1-\gamma(Tmoy-Tr)]H_{cp}(\beta)}} \cdot \frac{\mathbf{E_m}}{\mathbf{\eta_{ond}}} \quad (1)$$

G: Standard solar radiation (1000 W/m²).

$H_{cp}(\beta)$: Daily solar radiation on modules surface at titled angle β [Wh/m^2]

F_m : Connecting factor, generally we use MPPT with factor equal to 0,9.

: Cells temperature coefficient s (between 0,004 and 0,005 /°C for silicon modules).

T_{moy} : Average temperature during sunshine, T_r: Reference temperature (25 °C).

The system operate with alternative current, the inverter efficiency is η_{ond}= 0.95.

The number of modules N_m is calculated by the following relation:

$$N_m = \frac{P_{cc}}{P_{cm}} \quad (2)$$

Where: $\mathbf{P_{cm}}$ is the PV module pick power (we choose P_{cm}=285 W).

In each sub-area, the calculation for well sample is carry out basing on the statistics provided by the exploitation service of Sonelgaz Ouargla. The results presented in figure 4 show that although low well depth, high daily consumption (567.03 kWh) and large number (397) of modules is required for the well of Gara Krima (Rouissat) that is due to the supplementary supply for a large number of hectares newly attributed, but, the well of Beni Sessine (Ain El-Beida) registries a reasonable number of modules (60) with daily consumption at 84.96 kWh and small well depth.

VI. COST OF ELECTRICITY SYSTEMS

In the calculations, the well of Beni Sessine (Ain El-Beida) is considered as base case. For the cost of conventional power, we take into account the price of equipments (transformer HT-MT, counters and

accessories) and grid connection works which is around 800 000 DZD (1 US Dollar = 75 DZD "Algerian Dinar"). In addition, the electricity tariff may registry progressive increase from 3% to 10% for each 5 years during the 25 years.

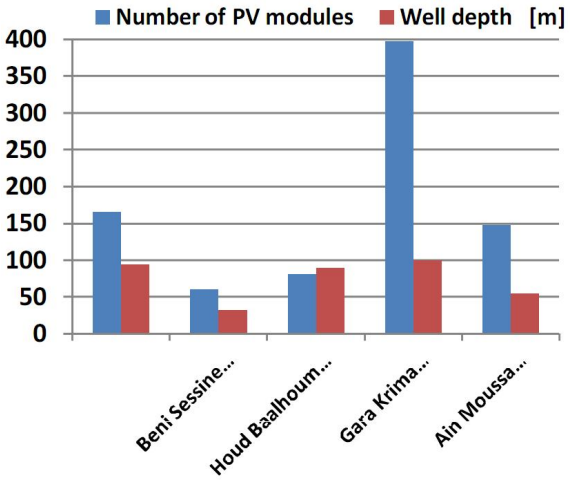


Fig. 4: PV modules number and well depth

For the solar system, the price of PV module is proposed by Algerian manufacturer "Condor" at 25650 DZD for the module of 285 W with lifetime more than 25 years. By adding transportation costs and mounting, the module cost reached 276000 DZD. For rooftop stations, inverter price index is based on a measure of inverters output power which reaches $ 0.711 (53 DZD) per continuous watt, and adding others fees (customs, transport) at 40%. The inverters have an average of 10 years as lifetime, so, for an operating period of 25 years, we add progressively 2.5 of inverters costs. Additional cost (wiring, fuses, switches) are estimated basing on the prices in the local market which can be valued at 40 000 DZD. Concerning the payback period, we plot three curves for grid and one curve for solar supply. From 2013, according to each scenario, the curves intersect at about fifteen, fourteen and twelve years. These periods represent the payback of PV system (see Figure 5). The electricity tariff for conventional system is at least 53 DZD/h against 40 DZD/h for PV system. Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity "Magnetization," or "Magnetization M," not just "M." Put units in parentheses.

Do not label axes only with units. As in Fig. 1, for example, write "Magnetization (A/m)" or "Magnetization ($A \cdot m^{-1}$)," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K." Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization (10^3 A/m)." Do not write "Magnetization (A/m) × 1000" because the reader would not know whether the top axis label in Fig. 1 meant 16000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 12 point type.

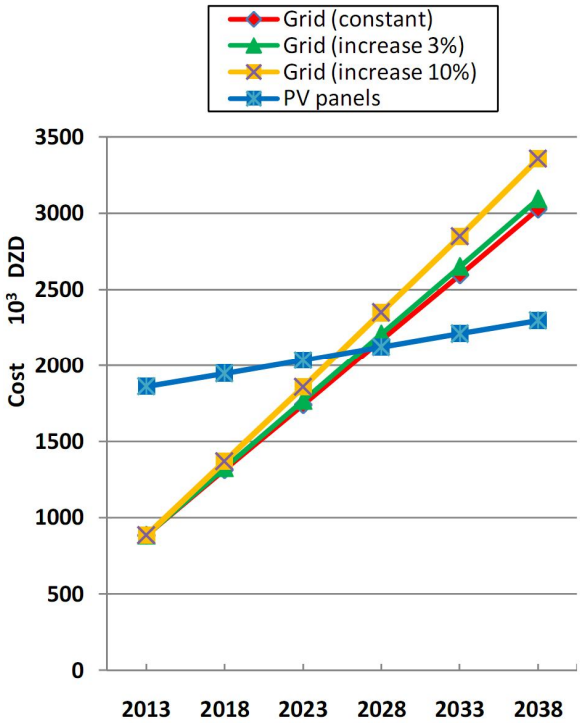


Fig. 5: Costs of water pumping systems

CONCLUSION

Ouargla region is rich in several date species which generate significant amount of wastes. In addition, it has significant underground water resources and wide plain lands. These potentials lead that the region can become an industrial pole for bio-ethanol production from palm dates.

Also, for future studies, other waste from palm branches can be valued in extracting bio-ethanol or producing thermal energy. For irrigation, there is high electricity consumption and the exploitation of some wells is still very expensive. So, some farmers can't ensure the payment of electricity bills, causing many disruptions in palm irrigation. Despite farmers receive 35% as subsidy for connecting to the electrical grid, the irrigation remains too costly.

Thus, we propose to plan new drilling for multiplying the water wells in order to allow their supplies by PV panels and to solicit state financial aid to support equipments acquisition. In addition, Ouargla region represents a small part of Algerian desert which can be exploited progressively in order to build a strong industry for ethanol production.

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