# THE UTILIZATION OF GEOTHERMAL ENERGY IN AGRICULTURE IN KEBILI REGION, SOUTHERN TUNISIA

MOULDI BEN MOHAMED,

*CRDA Kebili, 4200 - Tunisia*
*mobmo@mailcity.com*

**ABSTRACT**

Geothermal energy in the Kebili region, south of Tunisia, has multiple utilizations, which are mainly in agriculture. 95% of the thermal water is used for irrigation of oases and heating of greenhouses. Generally, when the water temperature is less than 40-45°C, it is used directly for irrigation, but when it exceeds 45°C, the water is cooled by means of atmospheric towers before being used for irrigation of 16,000 hectares of oases (The half of the total area in the country).

Geothermal energy is also used for heating and irrigating greenhouses, which is considered a promising and economically feasible application. The total area of heated greenhouses in the country has increased considerably and is today at 103 ha, in which 44% are located in the Kebili area. The utilization of the geothermal resources will, without a doubt, increase in the near future by the application of the remaining part of the greenhouse strategy. By the end of 2003, 13 ha will be added in the region, which represents an increase of 29%.

**Keywords**: Geothermal resources, direct utilization, oases, greenhouses.

## 1. INTRODUCTION

Geothermal Energy is heat derived from the earth. It is the thermal energy contained in the rock and fluid in the earth's crust. These resources can be classified as low temperature (less than 90°C), moderate temperature (90°C-150°C), and high temperature (greater than 150°C). The uses to which these resources are applied are also influenced by temperature. The highest temperature resources are generally used only for electric power generation. Uses for low and moderate temperature resources can be divided into two categories: direct use and ground-source heat pumps. Direct use, as the name implies, involves using the heat in the water directly for heating. (Information furnished by the Oregon Institute of Technology, GRC Homepage). The primary forms of direct use include swimming, bathing, space heating, agriculture, fish farming and industrial processes. In Tunisia, because of the low enthalpy resources, the use of geothermal energy is limited to direct utilization, especially in agriculture. The resources are localized mainly in the southern part of the country in the regions of Gabes, Kebili and Tozeur and utilized mostly for agricultural purposes. The government's policy in the beginning of the 1980's was oriented to the development of the oasis' sector and the main aim was to supply oases with geothermal water for irrigation. Therefore, in the Kebili area, about 35 boreholes are operating mostly for irrigation of 16,000 ha of oases after cooling the water in atmospheric towers. In 1986 the State started using geothermal energy for greenhouse farming by planting an area of 1 ha. The results of this experiment were encouraging and thus, the areas today have increased to 45 ha.

This report presents the main direct uses of geothermal energy in the Kebili region. The purpose is to describe this different utilization and to analyze the impediments to the agricultural operations. The study starts with an outline of the geothermal potential and resources in the concerned region. Following this, the utilization of groundwater in agriculture is discussed.

## 2. GEOTHERMAL RESOURCES IN KEBILI REGION

The region of Kebili is located in the southwestern part of the country. Geothermal resources are taken from the deep aquifer or CI: Continental Intercalaire, the largest in Tunisia. This aquifer is characterized by relatively hot water (30-75°C) and at depths reaching 2,800 m. Geothermal resources are located in a reservoir of 600,000 $km^2$ which covers the regions of Kebili, Tozeur, Gabes and the extreme south, and extends to Algeria and Libya. The CI aquifer is one of the largest confined aquifers in the world, comparable in scale to the great artesian basin of Australia. The principal areas of recharge are in the South Atlas mountains of Algeria and Tunisia and the Dahar mountains of Tunisia (Edmunds et al., 1995). In the Kebili area, radiocarbon analysis has shown that the geothermal water is about 20-50 thousand years old and is of sulfate-chloride type (Agoun, 2000). The salinity reaches 4 g/L and the water is utilized mainly for agriculture purposes.

Because of the existence of cold artesian water in the past and because of the limited area of the oases, the geothermal resources were initially exploited for bathing and washing. This was in the beginning of 1950 and 1960. After that, and because of the abundance of water in some oases and the large expansion of areas, these resources were utilized for oases's irrigation (see Figure 1). The important period of borehole drilling was in 1985 and 1986 (twelve wells) and in the beginning of 1990 (eight wells). Drilling activity was stopped in 1994, and then started again in 1999 and 2000 (five wells). From 1952 to 2000, 35 wells were drilled in the region.

*Figure 1: A well used for oases irrigation.*

## 3. GEOTHERMAL UTILIZATION (RESULTS AND DISCUSSION)

Major direct utilization projects exploiting geothermal energy exist in about 60 countries, and the estimated installed thermal power is 16,2 MWt. The majority of this energy use is for space heating (37%), and swimming and bathing (22%) (Lund, 2002). In Kebili region, 95% of the geothermal resources is utilized for agricultural purposes: 77% for oases and 19% for greenhouses. The remaining part (4%) is used for bathing (hammams), tourism (hotels and pools), washing and animal husbandry. The use in greenhouses increases by about 2% compared to the last year (17%) because of the increasing of areas. Figure 2 shows the different direct geothermal uses in the area.

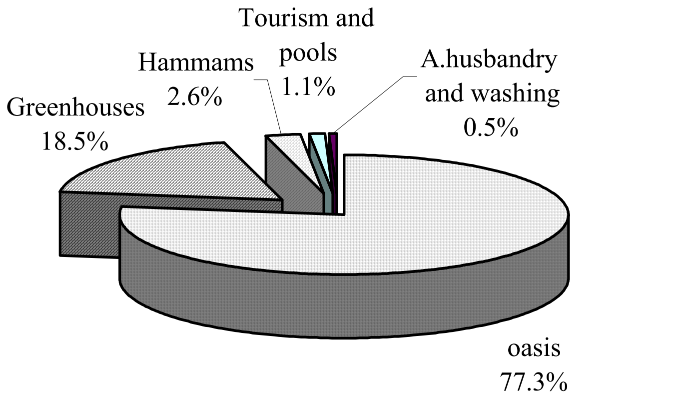



*Figure 2: Geothermal uses in Kebili area*

**3.1 IRRIGATION OF OASES**

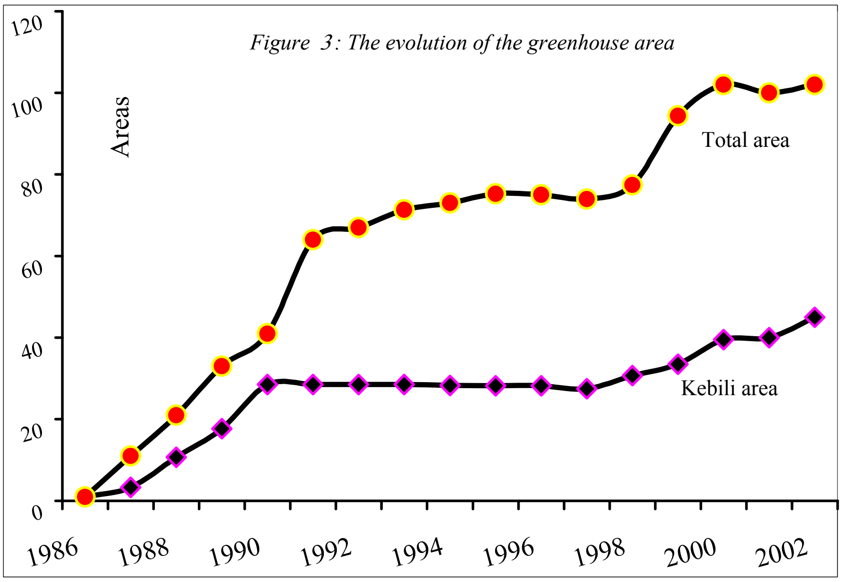
The region of Kebili is characterized by desert climate. The annual precipitation is irregular and generally less than 100 mm. The maximum temperature is about 55°C (July) and the temperature range (the difference between maximum and minimum temperatures) is very high. These difficult conditions require a large amount of water to maintain the humidity inside the oases system. The major part of the geothermal water is used for irrigating 16,000 ha of oases (77%) but all the resources taken from the Complexe Terminal aquifer (CT) are used for irrigation. The water temperatures varies from 27°C to 73°C. Generally, water less than 45°C is used directly for irrigation or cooled by means of multiple ponds or cascaded. When the temperature exceeds 45°C, the water is cooled by means of atmospheric towers before being used for irrigation. In normal conditions, we can drop the temperature to 30-32°C.

**3.2 HEATING OF GREENHOUSES**

Greenhouses are one of the largest low enthalpy energy consumers in agriculture. Geothermal heating of greenhouses started in Iceland in 1924. By the end of 1970 some glasshouses were heated in Yugoslavia. Other countries followed the experience and nowadays, there are around 940 ha worldwide using geothermal energy for heating which represents 12% of the total energy use. In Tunisia, in addition to irrigation of oasis, the geothermal water is used for heating plastic greenhouses. The utilization of geothermal energy recently started in the country as an experiment. The results were very encouraging and led to the idea of a Geothermal Utilization Project in Agriculture (PUGA-project, TUN/85/004). In 1986 the government started to use geothermal energy in greenhouses in southern part of the country. After one year, many demonstration projects in several places had been established. The exploitation of geothermal resources for heating greenhouses on the edge of the desert represents a promising alternative for the development.

### 3.2.1 Evolution of areas

According to Popovski (1993), the leading countries using geothermal energy in greenhouse growing in the world are USA (183 ha), Hungary (130 ha), China-Taiwan (60 ha), Macedonia (51 ha), former USSR (25 ha), France (24 ha), Spain (20 ha) and Iceland (18 ha). In 1993, Tunisia occupied the third position with 71 ha, after the USA and Hungary. But, based on papers for WGC2000 (Lund, 2002), Tunisia occupied the first place with 102 ha. Starting with one ha as an experiment in 1986, the total area has increased considerably. Indeed, the area reached 21 ha in 1988 in which 51% were in the region of Kebili. In 1992, the total area covered was 67 ha (43% in the region). The total area continues to increase, reaching near 80 ha in 1998, in which the region represents 40%. Today, the total area is 103 ha, in which 44% are located in the Kebili area. Figure 3 shows the evolution of the greenhouse area in the country and in the region.




Plastic houses were attributed in the beginning to small farmers with two units of houses. The first experience was in the Limagues locality where 1 ha was planned in 1986. Further, the areas reached 18 ha in 1989. Since 1990 this sector has stagnated in the range of 28 ha, but started increasing again in 2000 and reach now 45 ha. The development of the greenhouse sector was very fast, at least for some farmers starting with two houses, holding now 5-6 greenhouses and sometimes 10 greenhouses. The utilization of the geothermal resources will, without a doubt, increase in the near future by the application of the remaining part of the greenhouse strategy. By the end of 2003, 13 ha will be added in the region.

### 3.2.2 Heating of greenhouses

Continuous low temperatures at 10-12°C during two successive days disturb the physiological behavior of plants. Paradoxically, temperatures higher than 30-38°C can provoke irreversible damage to crops. Normally, temperature variation should not exceed 5-7°C. In the south this is difficult to obtain, as the risk of temperature variation is frequent. In order to solve this problem, the use of geothermal water is a good solution, which can improve the climate inside greenhouses principally during the night. The heating is through pipes lying on the ground between the plants (see Figure 4).

*Figure 4: A typical greenhouse heating system*

Several types of pipes have been tried and polypropylene pipes were selected. Generally, an average of 8-10 loops are used per house and they are connected with the system by an easily operated valve. For heating greenhouses in the Kebili region, 13 wells are operating to supply 22 different sites. An area of 45 ha is heated with a water temperature varying from 45 to 73°C. As mentioned above, the greenhouses in the region consume about 19% of the total geothermal water. About one third of the total flow rate of the wells supplying the sites is intended for the greenhouse heating. The rest is mainly used for oases irrigation. In the region and during the cold period, the need for heating is estimated to be 6.45 L/s per ha (Ben Mohamed, 2002), which corresponds approximately to the recommended flow rate (6 L/s/ha or 0.3 L/s per greenhouse), but this amount depends strongly on the temperature of the water and the climate conditions. The need for greenhouse heating is only six months, mostly during the night. Farmers start heating in November-December and stop it in April. The duration lasts 14 hours per day. This means that they open the heating system in the afternoon when they finish working and stop it the next morning when they reach the farm (Ben Mohamed, 1995).

### 3.2.3 Irrigation of greenhouses

After the thermal water has been used for heating it is collected in concrete ponds for subsequent use for irrigation. These ponds need to be large to store all the cooled water until it is used for irrigation. In some projects, farmers utilize very small and simple ponds with plastic linings, which are cheaper and very practical. Their dimension varies from 40 to 80 $m^3$. Generally, these ponds are used for the irrigation of an open field area close to greenhouses. The need for water irrigation during the growing period is very low (0.6 L/s/ha) compared to heating. Farmers utilize a local system in which water circulates inside a perforate pipeline lying on the ground. The chemical composition of the geothermal water used in irrigation must be monitored carefully to avoid adverse effects on plants because of the high salinity.

## 4. CONCLUSION

Geothermal water is used both for irrigation of oases and heating of greenhouses. For water saving purposes, the use in a cascade way starts recently in the region. For the new projects, there are a good relation between the users and water from greenhouses goes directly to oases for irrigation. The need for heating and irrigating a greenhouse is respectively estimated at 0.3 and 0.03 L/s. The rest (the return water) which represents 90% (0.27 L/s) should supply the oases surrounding the area, but this is often difficult to achieve. It is important to note that the location of a greenhouse project near the oasis is preferred and a combination greenhouse-oasis must be considered in the future. Normally the return water should supply the old oases or the new ones close to the greenhouses project, but, generally in old projects, there are conflicts between users. In the region, the total amount of water returned from the greenhouses to the oases represents only 68 % of the available water. This means that one third (32%) of the total heating flow rate is wasted.

**REFERENCES**

1. Agoun, A., 2000: Exploitation of the continental intercalaire aquifer at the Kebili geothermal field, Tunisia. Report 2 in: *Geothermal Training in Iceland 2000*, UNU GTP, Iceland, pp. 1-28.

2. Ben Mohamed, M., 1997: Agricultural geothermal utilization in Kebili region, Tunisia. Report 2 in: *Geothermal Training in Iceland 1997*, UNU GTP, Iceland, pp. 27-56.

3. Ben Mohamed, M., 2002: Geothermal utilization in agriculture in Kebili region, south of Tunisia. International workshop on possibilities of geothermal energy development in the Aegean region. *International Summer School on Direct Application of Geothermal Energy* and *Aristotle university of Thessaloniki*, Greece, September 2002, pp. 106-119.

4. Edmunds, W. M., Shand, P., Guendouz, A. H. Moulla, A. S., Mamou, A. and Zouari, K., 1995: *Recharge characteristics and groundwater quality of the grand erg oriental basin*. British Geological Survey, Wallingford, final report, 9pp.

5. Information furnished by the Oregon Institute of Technology, GRC Homepage

6. Lund, J. W., 2002: Direct heat utilization of geothermal resources. International course on district heating, agricultural and agro-industrial uses of geothermal energy. *International Summer School on Direct Application of Geothermal Energy* and *Aristotle university of Thessaloniki*, Greece, September 2002, pp. 17-31.

7. Lund, J. W., 2002: Introduction to geothermal greenhouse design. International course on district heating, agricultural and agro-industrial uses of geothermal energy. *International Summer School on Direct Application of Geothermal Energy* and *Aristotle university of Thessaloniki*, Greece, September 2002, pp. 131-136.