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# Geothermal Activities in Algeria

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## ABSTRACT

The most popular utilization of hot water springs is remaining the balneotherapy. The hot springs which are mainly located in the northern part of the country generate a total heat discharge of 240 MWt. The ten public thermal resorts are using about 40% of this heat discharge. Apart from some direct use in small research projects, the utilization of this potential was reserved to thermalism. But during the last few years, a significant interest for other uses of geothermal water is observed. Three sites have been selected for geothermal aquaculture projects. Fish farms in Ghardaia and Ouargla are using the albian geothermal water of the Sahara to produce about 1500 tons/yr of Tilapia fish. The third site is Ain Skhouna, located near Saida. Geothermal water at 40°C is used to fill ponds. 200 tones of Tilapia fish have been produced during the year 2008. A small geothermal heat pump project has also been realised in this region. The heat pump, a reverse one, is used for heating and cooling 12 classrooms, the library and the restaurant of a primary school. Hammam Sidi Aissa geothermal water (46°C) is used for this purpose. A similar project will be initiated at Khenchla (North East of Algeria). Electricity production from geothermal water is also planned. A private company attempts to install the first binary cycle power plant near Guelma (NE of Algeria).

## 1. INTRODUCTION

The majority of the overall energy production in Algeria is provided by hydrocarbons (96%), the rest by hydraulics. The national energy policy aims to increase the contribution of renewable energy sources in the national energy balance sheet, as well as encourage the use of higher efficiency energy systems. Some texts of law have been adopted in the frame of the renewables. Article 33 of the law related to the energy control, stipulates that tax advantages in terms of customs duties may be granted for projects promoting renewable energy. The authorities are especially interested in the production of electricity. Some projects have been launched such as the 150 MWe solar - diesel power plant of Hassi – R'mel (Sahara), the 10 MWe wind-diesel project of Tindouf (Western Sahara) and the solar electrification of 548 rural households. Geothermal water, which was reserved only for the activities of the spa, began gradually to be used in others areas. The few geothermal projects mentioned in this paper, are mostly initiated by private individuals and have economic objectives. However, for investment projects, authorities provide funds support up to 80% of the total costs. This is the case for projects in relation to fish farming or agriculture. Small projects such as heat pumps installation are at the expense of local authorities.

## 2. GEOLOGY BACKGROUND

The mountains belt called the Saharan Atlas separates the country into two major zones: the northern zone which is still tectonically active, and the stable Saharan platform in the South.

The first zone includes the Tellian Atlas and the High Plains (Figures 1).

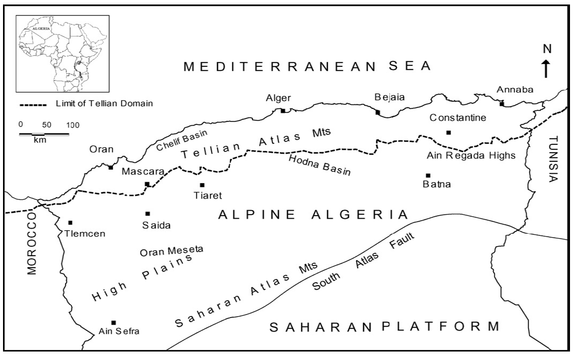


**Figure 1: Tectonic map of the northern Algeria.**

The Tellian Atlas is an orogenic belt constituted with superimposed nappes which derive from three major paleo-geographic domains, Wildi (1976): the "Domaine Interne", the "Nappe de Flyshs" and the "Domaine Externe". The first domain consists of a crystalline crust with a Palaeozoic to Tertiary cover and the calcareous belt which constitutes the "chaine calcaire" and the "nappes telliennes" (Mesozoic to Lower Miocene). The second and third domains are constituted with Mesozoic to Tertiary evaporates and carbonates. Units of the "Domaine Interne" are overlaying the "Nappe de flyshs", whereas the Nappe de Flyshs" is overlaying units of the"Domaine Externe".

This last alpine orogenic phase has been followed by magmatic activities along the coastal area during the Miocene.

The High Plains constitute the foreland (autochthonous) of the Alpine belt in Algeria. They are characterized by tabular structures. The main geological formations are limestone, marls and dolomites. These formations of Jurassic and Cetaceous become more detritic at the Lower Miocene, G. Duée (1973).

The Saharan Atlas belt is made with a series of very thick and folded geological structures where Jurassic and Cretaceous formations such as dolomites, limestone and marls are dominating.

The Sahara platform is a tectonically stable zone. Large sedimentary basins constitute hot water and hydrocarbon reservoirs.

## 3. GEOTHERMAL RESOURCES AND POTENTIAL

Units of the "Chaine Calcaire", the calcareous layers of "nappes telliennes" and limestone and dolomites of Tlemcen and Saida, are the main geothermal reservoirs of the northern region. These reservoirs are generally located at 500 to 1000 m depth. Nevertheless, some reservoirs of medium temperature were expected at about 2500 meters depth in the north eastern region. More detailed studies are required to confirm this assumption.

The scarcity of data has not permitted to evaluate the geothermal potential of the northern part of Algeria. However, the total heat discharge has been evaluated from the main hot springs and some drillings up to 240 MWt. These hot springs in which temperature ranges from 30°C to 98°C are mainly located in the North East and the West (Figure 2). Geothermal reservoirs of the North are not well defined. More exhaustive and detailed assessment is necessary to characterize these reservoirs and to have more precise information on the geothermal reserves and possibilities.

In the Sahara, the Albian geothermal reservoir has been better studied. The availability of data has allowed drawing up different maps for its characterisation and definition. This reservoir is confined in its northern part where it goes to almost 2600 meters in depth. The water temperature mean value is about 60°C. The maximum water temperature at surface is 80°C. The total flow rate from wells is over 10 $m^3/s$. The approximate heat discharge is about 700 MWth.

## 4. GEOTHERMAL UTILIZATION

The contribution of renewable energy (wind and solar) in the national energy balance is currently about 0.037% of a total power of 8000 MWe. According to the CREG report (2006), this rate will reach 2.8% in 2009 and 6% by the year 2015 (respectively 222 MW and 725 MW). Actually, this concerns hybrid projects as the 150 MW Gas-Solar one of Hassi R'mel, the 10 MW wind-diesel of Tindouf and others similar projects planned by New Energy Algeria Company (NEAL).

Due to the lack of high temperature geothermal reservoirs, authorities paid little attention to geothermal energy development. They have not planned any project that would allow geothermal energy to compete with solar and wind. From the total available thermal power, only a small amount is actually used. Balneology, which is the largest utilization of thermal water, is using about 100 to 140 MWt from a total water heat discharge of 240 MWt in the North. The calculated capacity for some sites (Table 3) is about 55 MWt. This value is lower than the available one since hot water is often cooled or mixed with cold water to have a more comfortable temperature. The albian geothermal potential of Sahara is practically not used. The two thermal resorts located in this area (Hammam Salihine at Biskra and Hammam Zalfana at Ghardaia) are using about 10 MWt of the total heat discharge.

Apart from some small geothermal direct use projects, Fekraoui and Kedaid (2005), geothermal energy began gradually to involve local authorities and individuals who find in it, an economical interest. During the last few years, number of projects has been completed. Others direct use projects are planned.

The most important planned project is concerning the electricity power production by the binary cycle technology. An Icelandic company of Algerian rights, KALDARA Green Energy, has been installed recently in Algeria. This company expects to install the first binary cycle power plant on the area of Hammam Meskhoutine, in the North Eastern part of the country. A reconnaissance survey will be launched shortly.

The second kind of projects is geothermal aquaculture. This activity is encouraged by the government which provides financial support up to 80% of the total project cost. Three fish farms have been built by individuals on different sites. The Saida (Ain Skhouna) fish farm consist on 33 ponds covering a total surface area of 49500 $m^2$, and other facilities such as, hatchery, laboratory, preliminary ponds, etc. A drilled hole provides 60 l/s of warm water (30°C) to feed the fish farm. 200 tons of Tilapia fish were produced in 2008. The expected annual production is 500 tons. The other two sites are located at Ouargla and Ghardaia localities (Sahara). Drill holes provide 44 l/s of water at 21°C for Ouargla and 150 l/s of water at 28°C for Ghardaia. About 1500 tons of Tilapia fish are produced per year. Cultivated species are Tilapia Nilotica and red Tilapia.

Probably Saida (Figure 1) is the first site in Algeria, which is using a geothermal heat pump. This reversible heat pump of 34 kW is used for heating and cooling 12 class rooms, the library and the restaurant of a primary school. Hot water (46°C) goes firstly trough the heat pump before it is used for bathing. The water exits at 39°C. This system permits to have comfortable temperatures of about 30°C during the cold period and 15°C in summer.

A similar geothermal heat pump project is planned for Hammam Salhine near Khenchela locality.

## 5. CONCLUSION AND DISCUSSION

The advantage of geothermal energy as compared to other renewables is the permanent availability of the resource independently to seasonal changes. This resource which is relatively abundant in Algeria is not totally used. Authorities are focusing only on the development of tourism and spa activities. Moreover, a low from the Ministry of Tourism prohibits any other activity using natural hot water (hot springs) other than this purpose. The previously or currently mentioned geothermal direct use projects, are actually using pumped hot water through boreholes. The upstream or downstream use of geothermal water does not, in fact, interfere with spas activities, but will allow saving energy and money. The multiplication of direct use of geothermal projects by individuals will be certainly, the best way to interest the authorities for the development of geothermal activities.

## 6. ACKNOWLEDGEMENT

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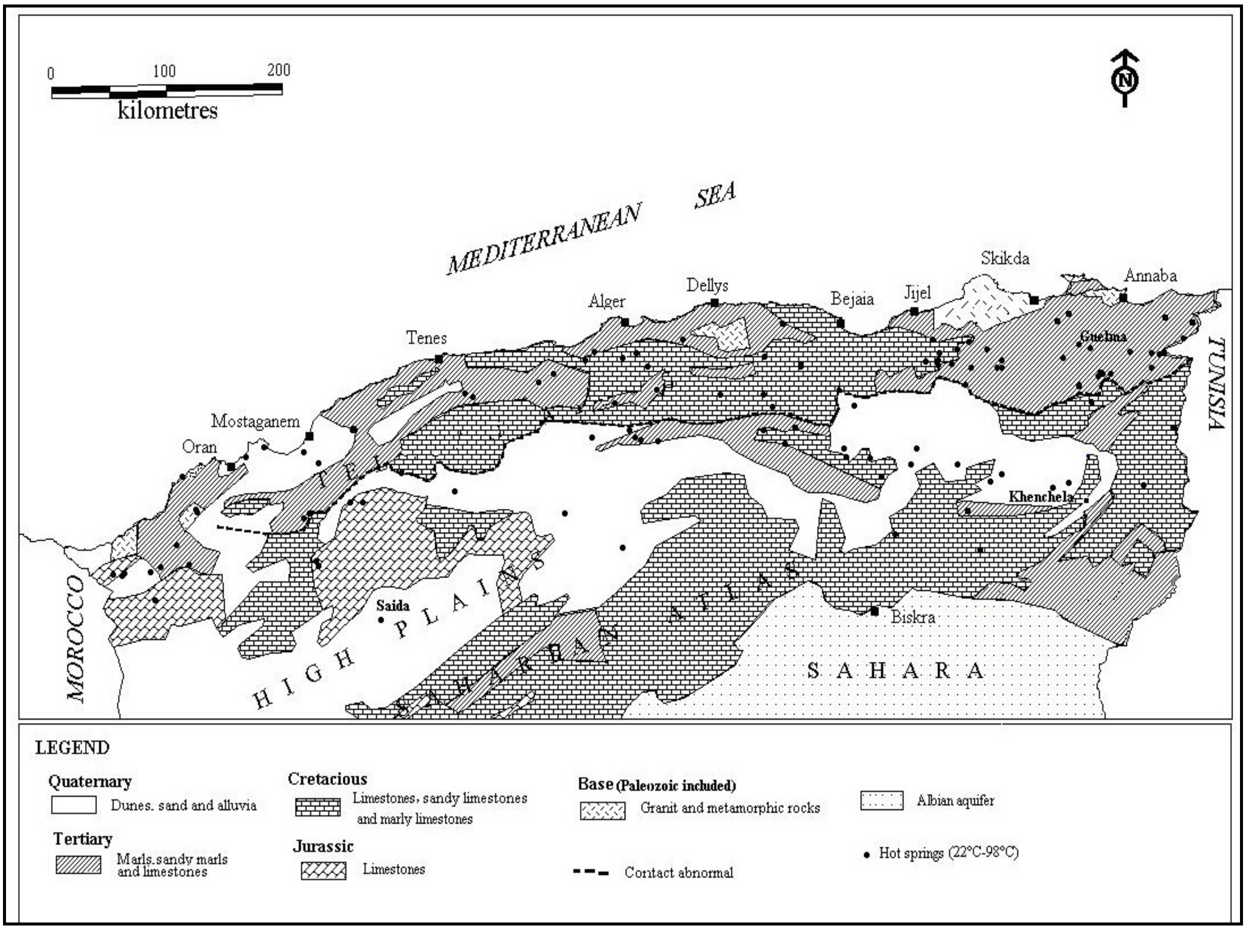


**Figure 2: Geology and main hot springs location sketch map**

**TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY**

| | Geothermal | | Fossil Fuels | | Hydro | | Nuclear | | Other Renewables (Solar, wind) | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr |
| In operation in December 2009 | | | 8283 | 40000 | 300 | | | | | | 8665 | |
| Under construction in December 2009 | | | | | | | | | 222* | 1194* | | |
| Funds committed, but not yet under construction in December 2009 | | | | | | | | | | | | |
| Total projected use by 2015 | | | 11800 | 55000 | | | | | 725* | 3700* | 11960 | |

NB: (* = Cogeneration solar-gas, wind-diesel)

## TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

[1] I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

[2] Enthalpy information is given only if there is steam or two-phase flow

[3] Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. ($^o$C) - outlet temp. ($^o$C)] x 0.004184 (MW = $10^6$ W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[4] Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. ($^o$C) - outlet temp. ($^o$C)] x 0.1319 (TJ = $10^{12}$ J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

[5] Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

**Note:** please report all numbers to three significant figures.

| Locality | Type[1] | Maximum Utilization | | | | | Capacity[3] | Annual Utilization | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate | Temperature ($^o$C) | | Enthalpy[2] (kJ/kg) | | | Ave. Flow | Energy[4] | Capacity |
| | | (kg/s) | Inlet | Outlet | Inlet | Outlet | (MWt) | (kg/s) | (TJ/yr) | Factor[5] |
| Hammam Meskhoutine | B | 80 | 90 | 30 | | | 20 | 80 | 633.12 | 0.25 |
| H. Ouled Ali, Guelma | B | 83 | 50 | 20 | | | 10.4 | 83 | 348.4 | 0.13 |
| Ain Berda, Guelma | B | 100 | 28 | 20 | | | 3.3 | 80 | 84.4 | 0.03 |
| Mouhammadia well | B | 12 | 47 | 30 | | | 0.85 | 12 | 26.9 | 0.07 |
| Teleghma well | B | 10 | 48 | 25 | | | 0.96 | 10 | 30.33 | 0.09 |
| Hammam Boughrara | B | 7 | 37 | 20 | | | 0.5 | 7 | 15.7 | 0.07 |
| Hammam Bouhnifia | B, H | 9 | 68 | 35 | | | 1.43 | 9 | 45.1 | 0.16 |
| Hammam Chiguer | B | 5 | 35 | 20 | | | 0.3 | 5 | 9.9 | 0.06 |
| Hammam Rabbi | B | 6 | 47 | 25 | | | 0.5 | 6 | 17.4 | 0.09 |
| Ham. S.Aissa, Saida | B,C | 6 | 46 | 39 | | | 0.17 | 6 | 5.5 | 1 |
| Ain Skhouna, Saida | B,F | 60 | 31 | 20 | | | 2.76 | 60 | 87.0 | 0.04 |
| Ghardaia well | F | 150 | 28 | 18 | | | 6.3 | 150 | 197.8 | 0.04 |
| Ouargla well | F | 44 | 21 | 17 | | | 0.73 | 44 | 23.2 | 0.016 |
| Hammam salhine | B | 65 | 43 | 20 | | | 6.25 | 65 | 197.0 | 0.09 |
| **TOTAL** | | 637 | | | | | 55.47 | 617 | 1721.75 | 0.15 |

## TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. ($^o$C) - outlet temp. ($^o$C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. ($^o$C) - outlet temp. ($^o$C)] x 0.1319 (TJ = $10^{12}$ J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 ( MW = $10^6$ W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

**Note:** please report all numbers to three significant figures.

| Use | Installed Capacity[1] (MWt) | Annual Energy Use[2] (TJ/yr = $10^{12}$ J/yr) | Capacity Factor[3] |
|---|---|---|---|
| Individual Space Heating[4] | 1.4 | 45.1 | 0.16 |
| District Heating [4] | | | |
| Air Conditioning (Cooling) | | | |
| Greenhouse Heating | | | |
| Fish Farming | 9.8 | 308 | 0.99 |
| Animal Farming | | | |
| Agricultural Drying[5] | | | |
| Industrial Process Heat[6] | | | |
| Snow Melting | | | |
| Bathing and Swimming[7] | 55.47 | 1744.2 | 0.99 |
| Other Uses (specify) | | | |
| **Subtotal** | 66.7 | 2097.3 | |
| Geothermal Heat Pumps | 0.17 | 55 | 1 |
| **TOTAL** | 67.87 | 2152.3 | 0.78 |

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

**TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells)**

Include thermal gradient wells, but not ones less than 100 m deep

| Purpose | Wellhead Temperatu | Number of Wells Drilled | | | | Total Depth (km) |
|---|---|---|---|---|---|---|
| | | Electric Power | Direct Use | Combined | Other (specify) | |
| Exploratior | (all) | | | | | |
| Production | >150° C | | | | | |
| | 150-100° C | | | | | |
| | <100° C | 4 | | | | >2 |
| Injection | (all) | | | | | |
| Total | | 4 | | | | >2 |

**TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES** (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

| Year | Professional Person-Years of Effort | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 2005 | 1 | | 5 | | | |
| 2006 | 2 | | 5 | | | |
| 2007 | 3 | | 10 | | | 2 |
| 2008 | 3 | | 10 | | | 2 |
| 2009 | 1 | | 20 | | | 3 |
| Total | 10 | | 50 | | | 7 |

Note: data are approximate

**TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$**

| Period | Research & Development Incl. Surface Explor. & Exploration Drilling | Field Development Including Production Drilling & Surface Equipment | Utilization | | Funding Type | |
|---|---|---|---|---|---|---|
| | | | Direct | Electrical | Private | Public |
| | Million US$ | Million US$ | Million US$ | Million US$ | % | % |
| 1995-1999 | | | | | | |
| 2000-2004 | 0,07 | | | | | 100 |
| 2005-2009 | 0,6 | | 1,25 | | 20 | 80 |

Nota: Approximate evaluation.