Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Geothermal Resources and Uses in Algeria: A Country Update Report

Amor Fekraoui and Fatima-Zohra Kedaid

Centre de Développement des Energies Renouvelable, BP. 62 Route de l'observatoire Bouzaréah Alger Algeria

fekraoui@hotmail.com, kedaid@hotmail.com

Keywords: Spas, Hammam, geothermal waters, direct uses.

ABSTRACT

In Algeria, calcareous rocks, sandy limestone and sandstones of Mesozoic age constitute the main geothermal reservoirs. The total flow rate from the several hot springs of the North and the exploiting wells of the albian reservoir is about 12 m^3/s. The temperature of waters varies from 22°C to 98°C. The principal utilization of these hot waters is the balneology and in a more small scale, space and greenhouses heating. Eight hot springs are used as public thermal resorts for medical purposes, generally for treatment of rheumatism and some skin diseases.

The recent adoption of the renewable energies law by the government will certainly enhance the geothermal activities.

1. INTRODUCTION

The relatively low prices of the conventional energies (natural gas and fuel) and the national policy of the rural electrification, have certainly a negative incidence on the development of geothermal energy in Algeria.

More than 900 MWt could be recovered from the numerous thermal springs of the North and the exploiting hot water wells of the saharian reservoir.

Apart from the experimental greenhouses heating system of Ouargla and Touggourt, Fekraoui and Abouriche (1995), and the recent geothermal installation of Hammam Meskhoutine and Hammam Bouhnifia (Figure 2), the balneology remains the principal utilization of thermal waters.

Recently, a text of law project has been submitted to the government for the development and promotion of the Renewable Energies. The main objectives of this law project are scientific and economical. It proposes a contribution of the renewable energies of about 10% of the total energy production by the year 2004.

2. GEOLOGICAL SETTING AND GEOTHERMAL RESOURCES

The South Atlas fault, that runs along the Tellian Atlas mountains, separates the country into two major zones:

The Northern zone that is still tectonically active and the stable Saharian platform to the South.

The Northern Zone comprises, from the North to the South, the Tellian Atlas, the High Plains and the Saharian Atlas (Figure 1).

The Tellian Atlas is an orogenic belt that is formed with several superimposed nappes which derive from three major paleogeographic domains, Wildi (1976):

The "Domaine Interne" wich is a part of the Alboran plate, consists of a crystalline crust with a Paleozoic to Tertiary cover and the Calcareous belt which constitutes the "Chaine Calcaire" with Mesozoic to Lower Miocene formations.

The Domain of the "Nappes de Flyshs".

The "Domaine Externe" with Mesozoic to Tertiary formations (evaporits, carbonates…).

Units of the "Domaine Interne" are overlaying the "Nappes des Flyshs" whereas the "Nappes des Flyshs" are overlying the units of the "Domaine Externe".

This last alpine orogenic phase has been followed by magmatic activities along the littoral at the Miocene.

The High Plains constitutes the foreland (autochthonous) of the Alpine belt of Algeria. They are characterized by tabular structures mainly made of Mesozoic formations. The Jurassic-Cretaceous sedimentary formations (limestone, marls and dolomite) become more detritic at the Lower Miocene, G.Duee (1973). Underlying the Mesozoic, the Paleozoic is made of sedimentary formations with some intrusions of granite and volcanic rocks. It outcrops trough vertical faults.

The Saharian Atlas Mountains are constituted of a series of very thick and folded structures of Jurassic and Cretaceous formations where dolomites Limestone and marls are dominating. This belt constitutes a geological, geomophological and climatological natural "barrier" as all these characteristics are very different from the North to the South.

The Saharian platform is a stable zone characterized mainly by sedimentary basins which constitute the hydrocarbon reservoirs and the geothermal albian nappe. To the south, in the Hoggar region magmatic activities took place from the Miocene to the Quaternary.

In the Northern part, the geothermal reservoirs are discontinuous and mainly made up of Jurassic and cretaceous formations.

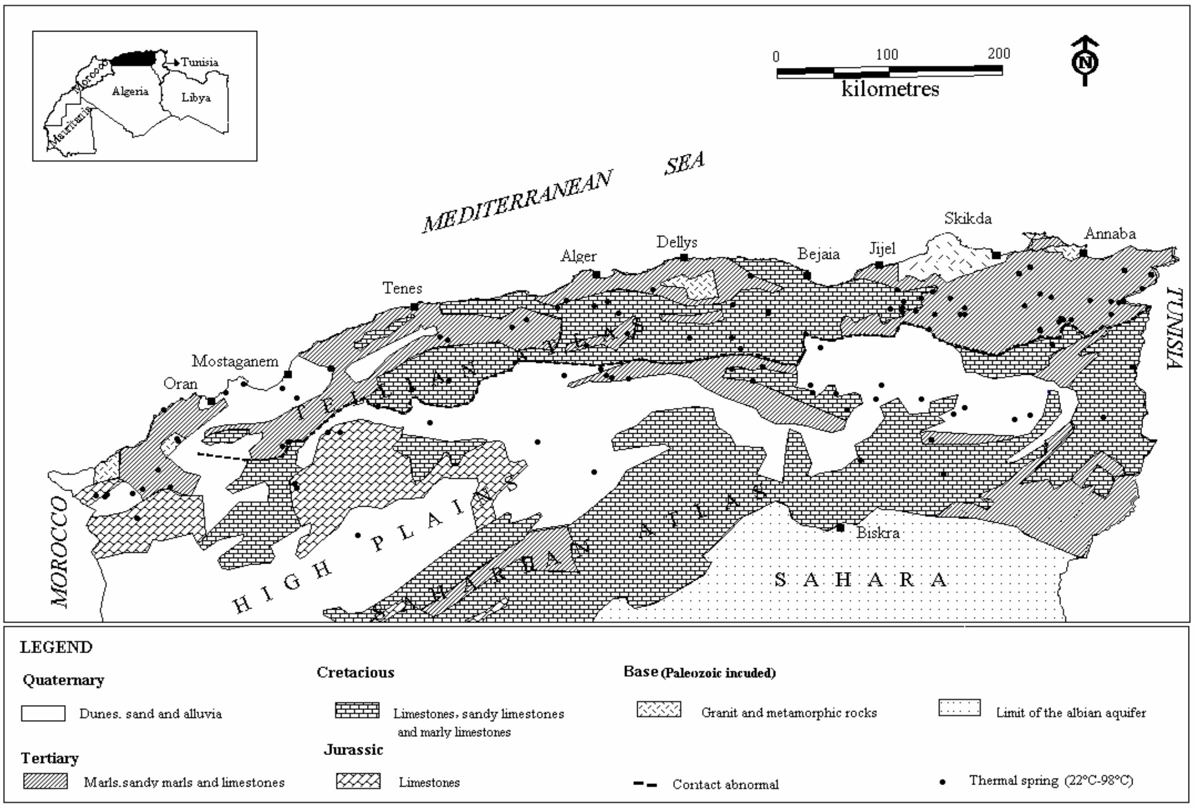

Figure 1: Geological sketch map of the northern Algeria.

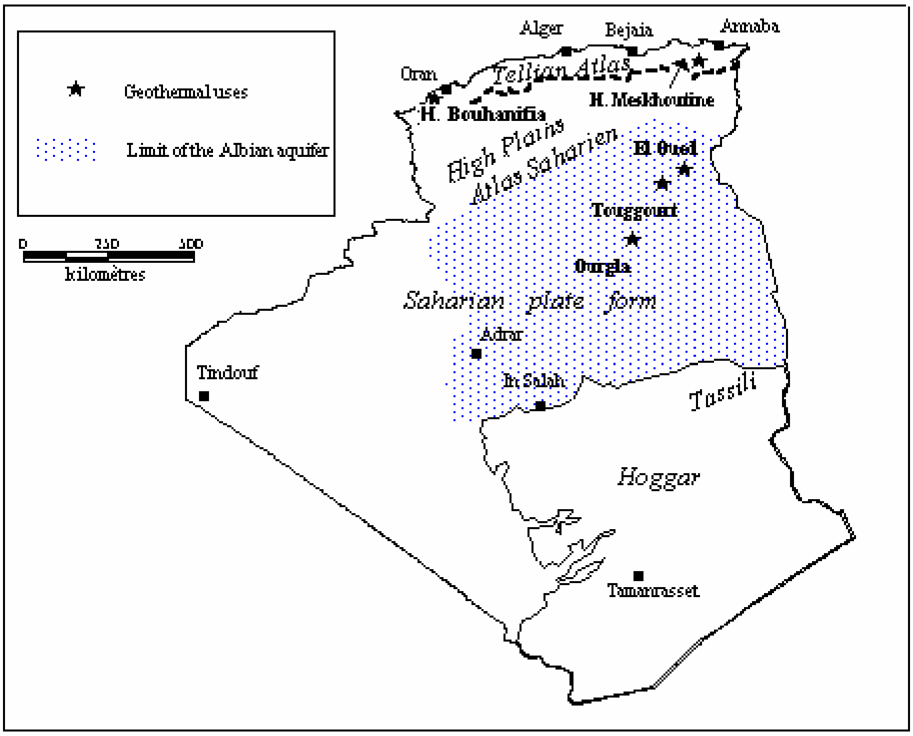

Figure 2: Location of the geothermal uses sites.

Calcareous rocks of the Tlemcen and Saida Mounts in the West, units of the “Chaine Calcaire” and the calcareous layers of the Tellian nappes, constitute the main geothermal reservoirs. These reservoirs are generally located at the depth of about 500m to 1000m at the West and deeper in the East (1000m-2600m). They are associated with many thermal springs and some of them were reached by boreholes**.** Hot waters have their temperatures ranging from 22°C to 98°C. Their pH is near the neutral value, whereas TDS varies from 0, 4 g/l to 10 g/l. The total flow rate from exploiting wells and hot springs is estimated to 1.8 m^3/s which corresponds to a heat discharge of 188 MWt. This value is concerning only the western region and part of the central and the eastern ones.

To the South, the albian sandstone formation extends on 600,000 km2 (Figure 2) and forms the geothermal saharian reservoir. This reservoir is confined in its Northeastern part and deeps to 1500-2600m. The average water temperature is 60°C which correspond to a normal geothermal gradient**.** The total flow rate from exploiting wells is about 10m^3/s and the mineralization is around 2g/l. In its western part the reservoir outcrops and water is fresh. Geothermal waters are generally cooled before their utilization for domestic and agricultural purposes. The heat discharge for the exploiting wells can be evaluated to 800 MWt.

GEOTHERMAL UTILIZATION

Balneology is the principal utilization of geothermal waters in Algeria. All the thermal sites are called Hammam (H. in the rest of the text) which has the same significance that the traditional “spas” described by Lund, (2002).

Among the 240 hot springs and hot water wells recorded in the North, there are 10 geothermal major spas and over 150 smaller ones. Eight of the major spas are public and considered as thermal resorts; they offer number of services such as physical re-education, massages and other health care given by a medical team. The most popular major spas resorts are: H. Meskhoutine; H. Guergour at the Est and H. Bouhanifia; H. Bouhadjar;; H. Bougharara; H. Righa at the West and H. Salihine at the South. (Table here after).

Main Characteristics of the Major Spas.

Spas	T°C	TDS (mg/l)	Flow rate (l/s)	Therapeutic utilization
H. Meskhoutine	98-95	1600	80	r, n, b, a
H. Guergour	44	3543	30	a, r,
H. Bouhanifia	68	1400	15	r, d, a
H. Bouhadjar	65	3100	10	r, n, d, s
H. Boughrara	37-43	398	15	r, u, a
H. Righa	68	2400	8	r, a
H. Salihine	70	2082	65	a, r, s

r: rheumatism; n: neurology; d: digestive; b: breath; u: urology; s: skin treatment; a: arthritis.

Many small spas are considered by people as well for their therapeutic properties as for their relationship to the popular beliefs. Some of thermal waters such as H. Ouled Sidi Slimane and H. Chiguer are well known for their properties to eliminate stones from kidneys; Their mineralization is very low (400-800 mg/l).

The direct utilization of geothermal waters in others domains is very limited. Additionally to the projects of Touggourt and Ouargla where 7200m2 of greenhouses are heated by the albian geothemal water, Fekraoui and Abouriche (1995), a new project of heating 10 000m2 of greenhouses at El Oued locality (Figure 2) will be nearly achieved if funding problems are resolved.

Geothermal waters are also used in space heating. At H. Bouhnifia resort, geothermal waters are directly used to heat a building of 50 rooms. The heating system is very simple and doesn’t use any heat exchanger. At the out let, the waters that have been cooled from 68°C to about 40°C, are collected and used for bathing. A similar heating system has been used at H. Meskhoutine resort to heat about 120 bungalows. The waters at 98°C were cooled to a more supportable temperature to be used in the swimming pools and private baths. Presently this heating system doesn’t work anymore because of the scaling problems.

CONCLUSION

Even though the Algerian geothermal resources are considered as of low temperature type, they offer the possibility to economize hundreds of thermal Megawatts. The contribution of geothermal energy today remains negligible because of low prices and availability of natural gas and fuel. But this situation will not last considering the gradual increase of the request and the prices of energy. The authorities take more and more conscience of the need for diversifying sources of energies and for preserving the environment.

REFERENCES

Duee G. : Cours sur la géologie algérienne, (1973).

Fekraoui A. and.Abouriche M. Algeria country update report, *Proceedings* of the WGC1995, pp.31-34 (1995).

Lund. J. W: Balneological use of thermal waters. International Summer School on Direct Application of Geothermal Energy, (2002).

Wildi W. : La chaîne tello-rifaine (Algérie, Maroc, Tunisie) : Structure, stratigraphie et évolution du Trias au Miocène. *Revue* de géodynamique et de géographie physique Vol.2, Fasc.3, pp.201-297, Paris, (1983).

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity)

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		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 2004			6345		280						6600	
Under construction in December 2004			400								400	
Funds committed, but not yet under construction in December 2004			/								/	
Total projected use by 2010			9700								9700	

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2004 (other than heat pumps)

1) D = District heating (other than heat pumps)

   B = Bathing and swimming (including balneology)

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

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184 (MW = 106 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. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 1012 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.

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Meskhoutine	B	80	90	20			23			
Oulad Ali	B	83	50	20			10,8			
Ain Berda	B	100	28	20			3,4			
Soukhna	B	83	50	20			10,4			
F, Mohammadia	B	12	47	20			1,35			
Teleghma	B	10	48	20			1,17			
Bougharara	B	7	37	20			0,5			
Bouhanifia	B, D	9	68	20			1,8			
Chiguer	B	5	35	20			0,3			
Bouhadjar	B	5	64	20			0,9			
Rabi	B	6	47	20			0,7			
El biban	B	2	80	20			0,5			
Essalihine	B	65	43	20			6,3			
TOTAL							**61**			

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2004

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°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. (oC) - outlet temp. (oC)] x 0.1319 (TJ = 1012 J) or= Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.031

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 106 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.

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]			
District Heating [4)]			
Air Conditioning (Cooling)			
Greenhouse Heating	2,3		
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]	150		
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps			
TOTAL	152,3		

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, 2000 TO DECEMBER 31, 2004 (excluding heat pump wells)

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

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)					
Production	>150^o C					
	150-100^o C					
	<100^o C		>5			>2
Injection	(all)					
Total						

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

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000	10		6			
2001	10		6			
2002	10		6			
2003	9		7			
2004	9		8			
Total	9		8			

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US$

Period	Research & Field Development		Utilization		Funding Type	
	Development Incl. Surface Explor. & Exploration Drilling Million US$	Including Production Drilling & Surface Equipment Million US$	Direct Million US$	Electrical Million US$	Private %	Public %
1990-1994			0.037*			100
1995-1999						
2000-2004						

*For greenhouses only.