GEOTHERMAL EXPLORATION AND DEVELOPMENT ACTIVITIES IN GREECE DURING 1990-1994

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ABSTRACT

Geothermal research that started in 1970 in Greece has revealed a rich geothermal potential in both high and low enthalpy resources spread amongst numerous geothermal fields. During the last five years related exploration activities were focused mainly on the low enthalpy fields of Thrace and Macedonia and in the field of Soussaki (Central Greece). In the region of Magana (Thrace) a new. very promising geothermal field has been identified by 21 exploration and 3 production wells. Country wide geothermal development has resulted in approximately 160 acres of geothermal heated greenhouses in operation (1994), as well as bathing installations at 38 sites. The most notable geothermal development is the construction of a heat distribution plant in Nea Kessani. On the other hand, the geothermal power plant of Milos island has remained shut down since 1988.

1. INTRODUCTION

Favourable geologic conditions prevailing in Greece, indicate very promising geothermal potential. Areas belonging to the active south Aegean volcanic arc, are privileged with high enthalpy ($T > 180$ °C) geothermal resources (Milos and Nisyros islands). Low enthalpy ($T < 100$ °C) geothermal fields however. are more common within Greek territory. There are also proven possibilities for medium enthalpy geothermal fields (100-180 °C).

The most important basins partially or totally explored are: Alexandroupolis basin (Aristino field), Xanthi-Komitini basin (Nea Kessani field). Delta Nestos basin (Eratino and Magana fields). Strymon basin (Sidirokastro, Nigrita and Iraklia fields). and Mygdonia basin (Langadas, Nymfopetra and Nea Apollonia fields). All geothermal fields in Greece are shown in figure 1.

The very promising high enthalpy projects of Milos and Nisyros islands are suspended for the moment. Although estimated 'geothermal resources" of these two fields may support over 200 MWe of installed power for a time period exceeding 20 years, only a pilot plant of 2 MWe has been installed in Milos since 1985, which has been shut down since 1988. as strong opposition against its operation has been encountered among the inhabitants and local organisations of the island.

On the other hand, during the last five years a series of low enthalpy projects have been completed in northern and central Greece, while others have begun showing very promising results. The depth of the investigated reservoirs varies between 100 and 500 meters. 3 deep boreholes however, with depths exceeding 1000 m, proved the existence of deeper permeable formations. Long range tests and reservoir engineering studies performed in some well known fields yielded a few hundreds to 1000 m^3/h of hot water of 40-80 °C with salinity varying between 0.8 and 49 gr/lt.

In the following paragraphs general information regarding the exploration and development of the recently explored low enthalpy geothermal fields (1990-1994) is presented. Special reference is made to the fields of Magana. Soussaki, Nea Kessani and the present status of direct uses. The main features of the above mentioned fields are summarised in Table 1, while the main features of the remaining low enthalpy geothermal fields of Greece are presented in Table 2.

2. GEOTHERMAL EXPLORATION

21. Field of Magana - Neo Erasmio (Thrace, Northern Greece)

The area of Magana lies at the eastern edge of the Delta Nestos basin. At present, 21 exploratory and 3 production wells have been drilled by I.G.M.E. These resulted in defining a low enthalpy reservoir, covering an area of 15 km^2. The reservoir is situated at depths between 200 and 400 m in the basal part of the post alpine sedimentary sequence (sandstones and conglomerates) and mainly at the top of the metamorphic basement (gneiss, granites, etc). The temperature is between 40 and 65 °C. Two types of fluids have been identified: Na-Cl rich fluids with TDS between 7-12 gr/l and Na-HCO, rich fluids with TDS up to I gr/l.

Systematic long range tests carried out in the three recently drilled productive boreholes, pointed out an optimum recoverable flow rate of 400 m^3/h of water at 63°C from the 3 boreholes. The total recoverable reserves could be estimated up to 30 MW. Combining the above mentioned characteristics with the sufficient reserves of fresh water and the proximity of the sea, the field of Magana provides the most efficient perspectives for future investments in the sectors of agriculture and fish farming.

2.2. Field of Nen Kessani (Thrace, Northern Greece)

During the last 4 years, derailed thermodynamic, chemical and reservoir engineering studies have successfully completed the background knowledge about this well known field. which appears until now as the most imponant low enthalpy system in Greece. The main hot reservoir (75-80 °C) is located within the clastic sediments of Paleogene at shallow depth (300-400 m).

The optimum production rate from the 4 productive boreholes has been estimated as 250 m^3/h for *20* years of exploitation. which corresponds to 1200 lt/h of conventional fuel. This value has resulted after taking into account the natural heat flow and the thermal energy stored in the aquifer. its temperature being 45-80 °C and its porosity *20%*.

Figure 1. Geothermal fields and applications in Greece

Table 1. Main characteristics of the recently explored geothermal fields in Greece:

REGION	Area km^2	Aquifer depth. m	Proven flow rate m^3/h	T°C of the aquifer	TDS, gr/lt	Type of water	Gas content	Wells expl./ prod. 1989	Wells expl./ prod. 1990-94
THRACE									
Aristino, Alexandroupolis	30+	50 - 150		38 - 50		Na-Cl-Ca-K			
		110-200		79+	10+			0	6
Nu Kessani	IS	100 -4w	250-350	45 - 80	5 - 6	$Na\text{-}Cl\text{-}HCO_3$	CO_2(h)	2110	2/5
Magana	15	200 - 400	400	55-65	- 1	$Na\text{-}HCO_3\text{-}Cl$		310	813
MACEDONIA									
Sidirokastro	10	20 - 50		35 - 67	1.3 - 2	$HCO_3\text{-}Na$		913	0/1
		250 - 400	150	35-57	1.3 - 2	$HCO_3\text{-}Na$		710	011
Nigrita	16	100 - 325	400	40 - 60	0.8 - 3.1	$Ca\text{-}HCO_3\text{-}Na$	CO_2(h)	911	0/5
	6	210	300	33-40	1+	$SO_4\text{-}HCO_3\text{-}Na$	CO_2 (l)	112	010
Nimfopetra	2	60 - 110	200	39-45	1+	$SO_4\text{-}HCO_3\text{-}Na$	CO_2(m)	5/1	010
Nu Apollonia	2	50 - 110	400	34-51	1+	$SO_4\text{-}HCO_3\text{-}Na$	CO_2(m)	311	011
STEREA HELLAS									
Soussaki	8	100 - 150	200+	60 - 80	39 - 42	Na-Cl	CO_2(h)-H_2S(m)	5/4	1/0
		500-	250	50 - 63	49	Na-Cl	CO_2(h)-H_2S(m)	0/0	0/2

(h) high content, (m) medium content. (l) low content

Table 2. Main characteristics of other low enthalpy geothermal fields in Greece:

Geothermal field	Surface area, km^2	Reservoir depth, m	Mean flow rate, m^3/h	T°C of the aquifer	TDS, gr/lt	Type of water	Wells expl./ prod.
Polichnitos, Lesvos isl.	10	50 - 150	400	67 - 92	12	Cl-Na	25/8
Lisvori, Lesvos isl.			20	68	11	Cl-Na	2/0
Argenos, Lesvos isl.	4	10 - 180	800	86	12	Cl-Na	0/3
Stipsi-Napi, Lesvos isl.	10	50 -150	30	42 - 67	1 - 5	Cl-Na	3
Kalloni, Lesvos isl.	10	50 - 200	300	25 - 30	0.5	$Cl\text{-}HCO_3$	6
Thermi, Yeras, Lesvos isl.	2+	20 - 80	150	40	1 - 2	$Cl\text{-}HCO_3$	5/1
Thermi, Lesvos isl.		10 - 50	200	60	35 - 38	Cl-Na	0/2
Mytilini, Lesvos isl.	10	50 - 150	500	30 - 35	1 - 2	$Cl\text{-}HCO_3$	0/15
Petra-Mythimna, Lesvos isl.	10	100 - 200	100	35 - 60	1+	$Cl\text{-}HCO_3$	4
Adamas-Zefyria, Milos isl.	50	10 - 100	200	30 - 90	5 - 30	Cl-Na	25/
Nisyros isl.		30 - 120	100	25 - 95	10 - 30	Cl-Na	10/3
Santorini isl.	10	50 - 350	-	25 - 70	3 - 30	Cl-Na	3/0
Nenita, Chios isl.	5+	100 - 150	100	30	1 - 2	$Cl\text{-}HCO_3$	3/0
Eratino, Delta Nestos	20+	600 - 800		70 - 90	6 - 8		14/0
Iraklia, Strymon Basin	25	200 - 400	200	40 - 62	1 - 2	HCO_3	10/1
Anthemountas, Thessaloniki		50 - 400		30 - 40	2	HCO_3	8/0
Eleochoria, Chalkidiki	30	60 - 250	1000	33 - 42	1.5	HCO_3	0/10+
Almopia Pellas (Aridea)	6	300 - 400		30 - 38	1		4/0
Lilantio, Evia isl.	2	- 350		25 - 32	8	Cl-Na	3/0
Aidipsos-Gialtra, Evia isl.	5+	0 - 100	400	50 - 81+	38	Cl-Na	4/6
Kamena Vourla - Thermopyles	5+	50 - 200	1200	35 - 46	8	Cl-Na	19/0
Andravida, Peloponissos	2	50 - 200	200	26	3.3	Cl-Na	3/0

A shallow production borehole has been scheduled for reinjection. Another well of 200 m depth yields 160 m^3/h artesian flow at 80°C. In addition, a deep well of 1000 m has drilled various productive aquifers from 300 m to bottom hole (basement). No production tests have been carried out at this well.

2.3. Field of Aristino Alexandroupolis (Thrace, Northern Greece)

This area is located at the western margins of a huge sedimentary basin. which extends within Turkey as well. Two main fault systems NNW-SSE and NNE-SSW wntrolled the spatial evolution of sedimentation and volcanism, which started in the middle Eocene.

Six shallow depth (110-210 m) boreholes drilled during 1994 pointed out the very high thermal potential of this region. The aquifers are located in the altered volcanic formations of high secondary permeability. A first upper aquifer zone (40-150 m) with a temperature range between 40-55 °C and salinity up to 5 gr/l, as well as a lower one (110-250 m) with temperature higher than 79°C and salinity exceeding 10 gr/l, have been identified. Until now surface and subsurface investigations have covered only a very limited part of the area of geothermal interest, which may well be over 50 km^2.

2.4. Strymon basin (Central Macedonia, Northern Greece)

The geothermal field of Nigrita (16 km^2) lies at the western margin of Strymon basin southwards of Serres city. The geothermal anomaly occurs mainly due to two deep fault systems trending NNE-SSW and NW-SE. which are normal and strike-slip structures. The reservoir is located in the basal conglomerates of Neogene age.

Five productive wells were drilled in the 90's, in addition to the ten exploratory boreholes, which had been drilled in 1983 reaching a maximum depth of 358 m, one of which is now productive. They have an average discharge rate of 70 m^3/h ani are being used for hearing greenhouses. Before the 90's a few private productive boreholes were drilled, which are also used for greenhouse heating. The minimum recoverable flow rate from the existing boreholes of the field has been estimated as 400 m^3/h.

2.5. Mygdonin basin (Central Macedonia, Northern Greece)

Three geothermal fields, Langadas, Nymfopetra and Nea Apollonia. have been identified in the vicinity of the lakes Langada and Volvi in Mygdonia basin. Fourteen exploratory boreholes have been drilled in the 80's wnfirming the geothermal interest pointed out by the thermal springs in the area. In the early 90's, long range tests performed at the five productive wells proved that the fields are extended over an area of 10 km^2. The top of the aquifer lies between 50 and 210 m, with temperatures ranging between 33 and 51 °C. The mean total flow rate of existing productive boreholes is 750 m^3/h, which represents a minimum potential of 11,000 TOE/year.

2.6. Field of Soussaki (Sterea Hellas, Cent-al Greece)

Soussaki geothermal field is located at the NW margin of the active volcanic Aegean arc. near Corinth canal. The stratigraphy of the field comprises of the plio-quaternary lacustrine deposits. the upper-cretaceous ophiolithic thrust. the upper-cretaceous to middle jurassic clastic formations. the lias limestone and the lower-jurassic - triassic dolomitised limestones.

Drilling exploration in the area. which was completed in 1992, included gradient boreholes. 5 shallow (<200m) exploration wells (1988) and 4 shallow production wells with 10 $^3/_4$" production casing, its shoe set at 100 m approximately, reaching depths between 110 and 200 m (drilled in 1989 and tested in 1990-91). It also included 2 deep production wells (SI and S3) reaching depths of 900 m and 1080 m respectively with $8^1/_2$" borehole and $9^5/_8$" production casing at 558 and 311 m respectively (1992).

Drilling exploration revealed three main permeable formations. two shallow ones in the neogene sedimenu (60-80 "C) and in the ophiolithic formations thrust (60-67 °C), as well as a deeper one in the limestones and dolomitised limestones with temperatures of 50-63 °C. Production rates yielded by the shallow wells were 50-90 m^3/h with the aid of a lineshaft pump, while the ones yielded by the deep wells were 160 m^3/h self flowing stimulated by air-lift for S1 and 100 m^3/h by continuous air-lift for S3.

Experiments with a Downhole Heat Exchanger consisting of $2^7/_8$" pipe that took place in a shallow production well resulted in 31°C inlet and 41.5°C outlet temperatures for 17.5 m^3/h flow rate.

In late 1992 a shallow well (-170 m) producing dry CO, was drilled (Mr D. Papadimitriou, GEMEE, personal communication).

3. GEOTHERMAL APPLICATIONS

Despite the large geothermal potential of the numerous Greek geothermal fields, exploitation of geothermal energy, excluding balneology, is currently limited to geothermal heated greenhouses installed in the fields of Sidirokastro, Nigrita. Nea Apollonia, Lagadas, Lesvos isle and Milos isle. They cover an overall area of 170 acres (including 12 acres of greenhouses that are not in operation). approximately 80 acres of which were commissioned during the last five years (1990-1994). A detailed description of these greenhouses is presented in table 3.

With the exception of heating of a major 'therapeutic" complex in Aidipsos. no fish-farming units. space heating applications or drying installations utilising geothermal energy are currently in operation (1994). At times, however, there have been small pilot plants or schedules to construct and operate such units.

Regarding high enthalpy applications, the 2 MWe power plant installed on Milos island has been shut down since 1988. due to strong opposition from local inhabitants and organisations quoting environmental reasons. not justified according to our point of view. We believe that the main causes of the problem are on the one hand, the false information the local people have about environmental aspects of electricity production from high enthalpy resources, and on the other. the actual environmental problems related mainly to H_2S emissions from the pilot power plant during its operation.

Production and injection tests performed at the deep wells N2 and N1 respectively in Nisyros island, showed that well N2 can produce 8 t/h steam and 11 t/h brine at 17 atm (198 °C), while N1 well cannot be used for reinjection due to self-sealing (Mr A. Ginis, PPC. personal communication). Although there were plans to drill 5 additional wells and to construct a power plant, further high enthalpy geothermal development on the island has been postponed. due to local people objection, who have been influenced by the events of Milos island.

On the other hand, the traditional balneology applications, namely bathing for leasure and healing purposes, abound in Greece (figure I). Such "spas" are sited in Sterea Hellas (Loutraki, Thermopyles, Kamena Vourla. Ypati and Platystomo), in Evia (Aidipsos and Gialtra), in Macedonia (Thermie or Anthemountas,

Table 3. Geothermal greenhouses in Greece (May 1994)

Field	Owner-ship	Area acres	Type	Heating system	Max fl. rate, m^3/h	T°C in	T°C out	Load factor	Cultivation
Sidirokastro	Municipal	6	glass	spiral PP-pipes Φ28	25	60	45	26 %	roses
	Municipal	4	glass	spiral PP-pipes Φ28	50	55	40	26 %	flower pots
	private	10	glass	spiral PP-pipes Φ28, water air-heaters	25 + 20	45 - 38	30	26 %	flowers
	private	4	glass	spiral PP-pipes Φ28, water air-heaters	25	40	30	26 %	roses
Nigrita	private	9	PE	PE pipes	150	55	30	13 %	vegetables
	private	8	glass, PE	finned tubes, transparent large PEpipes	67	41	30	10 %	flowers, vegs
	private	33	glass	H.E., reinjection	200	60	35	16 %	vegetables
	Municipal	4	glass	H.E., water air-heaters	50	55	35		roses
N. Apollonia	private	4.5	PE	PE pipes	45	47	35	16 %	vegetables
	private	7		transparent large PE pipes		42	18	28 %	vegetables
	private	4	glass	spiral PP-pipes Φ28	45	45	30	28 %	flower pots
	private	14	glass	spiral PP-pipes Φ28	40	48	33	17 %	roses, tomatoes
Langadas	private	7	glass, PE	spiral PP-pipes Φ28	40	36	27	28 %	roses
	private	2		transparent large PE pipes		36	27		vegetables
	Municipal	3		not in operation	-	-	-	-	-
Lisvori, Lesvos isl.	Municipal	4	glass	spiral PP-pipes Φ28	25	67	50*	22 %	roses
Yeras, Lesvos isl.	Municipal	4	double PE	spiral PP-pipes Φ28	30	38	28	17 %	vegetables
Polychnitos, Lesvos isl.	Municipal	9	pl.,gl.,PE	not in operation	-	-	-	-	-
	private	3.5	plastic	water air-heaters, spiral PP-pipes Φ28	7	85	30	20 %*	vegetables
	private	3.5	plastic	water air-heaters, spiral PP-pipes Φ28	10	85	30	17 %	vegetables
	private	3	plastic	spiral PP-pipes Φ28	6	85	30	20 %*	vegetables
	private	6.5	plastic	water air-heaters, spiral PP-pipes Φ28	25	85	30	15 %	vegetables
	private	4	double PE	water air-heaters, spiral PP-pipes Φ28	not connected yet				vegetables
Milos isl.	Municipal	7	glass, PE	PE pipes	6	45	30	65 %	vegetables
	private	5.5	plastic	PE pipes	15	47	25	27 %	vegetables

* estimation

Sidirokastro. Nigrita, Agistro. Aridea. Langadas, Nea Apollonia. Agia Paraskevi and Eleftheres Kavalas), in Thrace (Nea Kessani. Trianoupolis and Echinos), in Peloponissos (Methana. Kaiafa and Kyllini), in Ipiros (Preveza, Kavassila and Amarantos Koniua), in Thessalia (Smokovo), as well as in the Aegean islands (Lesvos, Limnos, Nisyros, Ikaria, Samos, Kithnos, Kos, Santorini and Samothraki).

Significant steps towards the exploitation of the geothermal fields of Nea Kessani and Soussaki have been taken in the framework of the VALOREN European Commission programme, although no end uses of the geothermal energy are currently in operation.

In particular, during the last five years 1 deep well (1050 m) has been drilled in Nea Kessani, while 3 wells have been connected in a hot water distribution plant. The installations include 2 production and 1 reinjection wells, submersible pumps, main tank, piping network, heat exchangers, controlling equipment, etc. The state bank of ETVA is responsible for the management of the field, which intends to allocate it to a private or municipal organisation, in order to promote its development. The relevant call for tenders has been released.

In Soussaki. the assembly of a similar heat distribution plant of smaller scale and the construction of a 3 acres geothermal greenhouse. are under way.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Wind		Total	
	Capacity MW,	Gross Prod. GWh/yr	Capacity MW,	Gross Prod. GWh/yr	Capacity MW,	Gross Prod. GWh/yr	Capacity MW,	Gross Prod. GWh/yr	Capacity MW,	Gross Prod. GWh/yr
In operation in January 1995	2	-	6552	31841	2524	2519	24		9102	34360
Under construction in January 1995	-		524		648					
Funds committed, but not yet under construction in January 1995	-		350 MECU							
Total projected use by 2000	12		8106	36470	3180	3370	150*		11448	39840

*unconfirmed

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRICAL GENERATION IN DECEMBER 1994

1) Data for 1994 if available, otherwise for 1993. Please specify which

Locality	Power Plant Name	Year Commissioned	No of Units	Status	Type of Unit	Unit Rating MW	Total Installed Cap. MW	Annual Energy Prod. GWh/yr	Total under Constr. or Planned MW
Milos	Milos Pilot Plant	1987	1	Out of operation	Condensing	2	2	- 10 (1988)	0
Nisyros									10
Total			1			2	2		10

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT IN DECEMBER 1994

1) I=Industrial process heat | D=Space heating
C=Air conditioning | B=Bathing and swimming
A=Agricultural drying | G=Greenhouses
F=Fish m d other animal tanning | O=Other (please specify by footnote)
S=Snow melting

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

3) Energy use (TJ yr)=Annual average water flow rate (kg/s) x [Inlet temp.(oC) - Outlet temp.(oC)] x 0.1319

Locality	Type (1)	Maximum Flow Rate m3/h	Temperatu Inlet	ation))utlet	ıthalpy (Inlet	J/kg) Outlet	Annual \verage ıow Rate kgir	Utiliza Ener Use (TJ/	Load Factor %
Sidirokastro	G	25	60	45					26
	G	50	55	40					26
	G	25	45	30					26
	ti	20	38	30					26
	G	25	40	30					26
Nigrita	G	150	55	30					13
	G	67	41	30					10
	G	200	60	35					16
	G	50	55	35					13*
N. Apollonia	G	45	47	35					16
	G	45*	42	18					28
	C	45	45	30					28
	G	40	48	33					17
Langadas	G	40	36	27					28
	G	11*	36	27					28*
Lisvori	G	25	67	50*					22
Yeras	G	30	38	28					17
Polychnitos	G	7	85	30					27*
	G	10	85	30					17
	G	6	85	30					20*
	G	25	85	30					15
Milos	G	15	47	25					21
Aidipsos	D	-	-						
Total	G	956							19

*estimation

TABLE 4. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES

1) Inst thermal power (MW)=Max. water flow rate (kg/s) x [Inlet temp.(oC) - Outlet temp.(oC)] x 0.004184
2) Energy use (TJ/yr) = Annual average water flow rate (kg/s) x [Inlet temp. (oC) - Outlet temp. (oC)] x 0.13 19

	Installed Thermal Power (1)	Energy Use (2)
Space heating	Yes	
Bathing and swimming	Yes	Yes
Agricultural drying		
Greenhouses	22.6	135
Fish and other animal fanning		
Industrial process heat		
snow melting		
Air conditioning		
Other uses (specify)		
Subtotal	22.6	135
eat Pumps	0.0183	demo

TABLE 6. INFORMATIONABOUT GEOTHERMAL LOCALITIES

1) Main type of reservoir rock
2) Total dissolved solids (TDS) in water before flashing. Put v for vapor dominated
3) N = Identified geothermal locality, but no assessment information available
   R = Regional assessment
   P = Pre-feasability studies
   F = Feasability studies (Reservoir evaluation and Engineering studies)
   U = Commercial utilization

Locality	Location 'o Nea :st 0.5 Degree		Reservoir		atus 3) 1 January 1995	:servoir Temp. (oC)	
	:atitud	Longitude	Rock 1).	I ssolved Solids mg/kg		:timated	easure
Aristino	N41	E26	altered volcanics	10000	N		79
Nea Kessani	N41	E25	clastic sediments	6000	F		80
Magana	N41	E24.5	sandstones conglomerates	12000	R		65
Sidirokastro	N41	E23.5	sandstones conglomerates	2000	U		61
Nigrita	N41	E23.5	basal conglomerates	3700	U		60
Langadas	N40 5	E23	metamorphic basement	1000	U		40
Nimfopetra	N40.5	E23.5	sands conglomerates	1000	F		45
N. Apollonia	N40.5	E23.5	sands conglomerates	1000	U		51
Eratino	N41	E24.5	limestones dolomites	8000	R		90
Iraklia	N41	E23	sands, clays sandstones	2000	F		62
Anthemountas	N40.5	E23	Sandstones Limestones	2000	U		40
Eleochoria	N40.5	E23	Limestones	1500	P		42
Aridea	N41	E22	Conglomerates	1000	U		38
Aidipsos	N39	E23	Travertine Gneiss	38000	U	92	81+
Gialtra	N39	E23	Neogene sediments	38000	U		43
Kamena Vourl	N39	E23	Brecias Conglomerates Limestones	8000	U		35
Thermopyles	N39	E22.5	Limestones Brecias Conglomerates	8000	U		46
Lilantio	N38 5	E24	Limestones sands	8000	N		32
Soussaki	N38	*E23*	*Limestones,* altered ophiolites brecias,sandstones	49000	F		80
Andravida	N31.5	E21.5	sediments	3300	N		26
Polichnitos	N39	E26	Ignimbrites	12000	U	92	86
Lisvori	N39	E26	Ignimbrites	11000	U		68
Argenos	N39.5	E26.5	Lavas Conglomerates	12000	P		86
Stipsi-Napi	N39.5	E26	Lavas	5000	R		67
Kalloni	N39	E26	Volcanic Sediments	*500*	R		30
Thermi Yera	N39	E26.5	Limestones	2000	U	40	38
Thermi	N39	E26.5	Limestones	38000	P		60
Mytilini	N39	E26.5	Limestones, Lavas neogene sediments	2000	R		35
Petra-Mythimr	N39.5	E26	Lavas, volcanics	1000	R		60
Milos isl.	N36.5	E24.5	Schists	75000	F		325
Nisyros isl.	N36.5	E27	Limestones, altered volcanics	75000	F		318
Santorini isl.	N36.5	E25.5	Limestones	30000	R		70
Nenita, Chios	N38	E26	Breccias Limestones	2000	N		30

TABLE 5. GEOTHERMAL HEAT PUMPS

Locality	Heal Source oC	COP - Factor	Heat Pump Fating KWt (Output)	Thermal Energy Used in Heating Mode 1). TJ/yr
Nm Faliro, Athens	17	4	3.3	demonstration
Koropi, Athens	20	3-4	15 Rating 5-7 output	demonstration
Total			18.3	

TABLE 9. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with a University degree)

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

Year	Professional Man Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1990	2	31	10	1	8	
1991	2	32	11	1	8	
1992	2	32	11	1	8	
1993	2	26	11	1	10	
1994	2	26	11	1	10	

TABLE 10. TOTAL INVESTMENTS IN GEOTHERMAL IN (1994) US$

Period	Research & Development Incl. Surf. Exp. & Exp. Drilling	Field Development Incl. Prod. Drilling & Surf. Equipment	Utilization		Funding Type	
	Million US$	Million US$	Direct Million US$	Electrical Million US$	Private %	Public %
1973-1982	23.15				0.6	99.4
1982-1992	25.13	3.34	0.4	Included in field devel.	10*	90*

* approximately