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

2005 Country Update for Eastern Caribbean Island Nations

Gerald W. Huttrer

Geothermal Management Company, Inc., Box 2425, Frisco, Colorado, USA

ghuttrer@colorado.net

Keywords: Caribbean, geothermal, volcanoes, OAS, Geo-Caraïbes

ABSTRACT

Excluding the two French islands of Guadeloupe and Martinique, there are nine English speaking island- nations within the Eastern Caribbean archipelago that have potential for the discovery of economically developable geothermal resources. From north to south, these are: Saba, St. Eustatius, St. Kitts, Nevis, Montserrat, Dominica, St. Lucia, St. Vincent, and Grenada. Since the 2000 World Geothermal Conference Country Update Report, there has been no geothermal development undertaken on any of these islands. Negotiations were held by and between several national governments and various potential geothermal developers, but, though several pre-feasibility studies were made and some preliminary agreements were reportedly reached, no resource confirmation work has been conducted recently. As this report is being written, the Organization of American States is planning to help St. Lucia, Dominica, and St. Kitts and Nevis identify and minimize constraints to the development of their renewable energy resources. Discussions between Governments and developers are reportedly in progress with regard to initiation of geothermal projects in Nevis, St. Lucia, Dominica, St. Vincent, and Montserrat. Hopefully, one or more of these efforts will mature and bear fruit in the near future.

1. INTRODUCTION

There are nine English-speaking island-nations within the Eastern Caribbean archipelago that have potential for the discovery of economically developable geothermal resources (Figure 1). From north to south, they are: Saba, St. Eustatius, St. Kitts & Nevis, Montserrat, Dominica, St. Lucia, St. Vincent, and Grenada. The governments of these nations all function in similar ways. They are modeled on the British system, being headed by a Prime Minister and governed by a Cabinet of Ministers whose numbers vary from country to country and from administration to administration.

The policies of each of these governments are focused on conduct of activities that will improve the lives of the citizens. The provision of reliable and affordable electric power is one of the common, primary objectives. The rationale for this is, of course, that inexpensive power will help keep the cost of manufactured items low, allow for the widespread installation of air-conditioned facilities that are attractive to tourists, and finally, to attract overseas investment into energy-intensive ventures that can ultimately benefit the nation.

In the geothermally prospective Caribbean nations, the Ministries of Public Works, Infrastructure and/or Overseas Affairs are commonly the ones responsible for energy-related matters. Unfortunately, there is little or no history of geothermal exploration or development in these islands, so there is a correspondingly low level of knowledge or understanding in these Ministries regarding these topics. The same can be said for the local educators, the members of the print and electronic media, and the general public. In the latter instance, there is often significant religiously or superstitiously based fear of "disturbing the local volcano" and stimulating an eruption if geothermal drilling is undertaken.

2. GEOLOGIC BACKGROUND

The islands of the Caribbean region comprise two eastward convex arcs. South of Montserrat, these arcs merge to form a single curvilinear island chain that intersects the South American continent at the Peninsula de Paria of Venezuela. The western island arc and its southern extension are of relatively recent (~5 MYBP-<0.02 MYBP) volcanic origin. The northern and eastern islands, though once loci of volcanism, are now mantled by thick sedimentary deposits.

The reason for the active volcanism is that the Caribbean islands occupy a crustal plate that is moving eastward along the North and South American Plates while it is being subducted by the westward moving Atlantic Plate (Figure 2). Accordingly, volcanic arcs typical of plate boundaries have formed over time and, in the Caribbean, each volcano or group of volcanoes forms the foundation of a discrete island.

The stresses related to the subduction and the strike-slip horizontal motions to which the region is being subjected result in constant tectonic readjustment. This is evidenced by frequent earthquakes, the generation of major NE-SW trending fracture systems and signs of magma movement at depths as shallow as 2-5 km.

This whole scenario is excellent for the development of geothermal reservoirs at economically drillable depths. There are heat sources beneath many of the islands, there are fault systems that, where they intersect, can comprise geothermal reservoirs of significant size, and there are fracture conduits, kept open and permeable by frequent seismicity, that can conduct meteoric recharge waters from the surface, to depths at which they can be heated to the thermal reservoir temperatures.

3. GEOTHERMAL RESOURCES AND POTENTIAL

Presented below, in descending order of development potential, are brief descriptions of the geothermal indicia on each of the nine prospective English-speaking islands:

3.1 Dominica

The likely presence of geothermal resources beneath Dominica is suggested by a boiling lake, numerous boiling hot springs, several large solfataras and very recent (<500 years old) volcanic activity. There are at least 5 geothermal centers, of which two (Wotten Waven and Soufriere/Galion) appear to have the best prospects for early development.

3.2 St. Lucia

Geothermal indicia on St. Lucia comprise a very large solfatara near the village of Soufriere, thermal springs nearby and very recent (<1000 years ago) volcanic activity including both phreatic and pyroclastic eruptions. Geothermal drilling conducted in the 1970's and 1980's disclosed the existence of a shallow (<700 meters deep) steam zone and of a hot (230^{o}C) resource at moderate depths. Unfortunately, the fluids produced from the latter zone are very chemically aggressive. The 1980's drilling also showed that there are areas of hot dry rock down to ~2 km and that the geology of the prospective area is far more complex than previously believed.

3.3 Nevis

On Mt. Nevis' northwestern, western and southwestern flanks, there are two solfataras (Farms and Cades), numerous thermal wells (Charlestown and Browns), and a large area of hydrothermal alteration (Belmont). Also, strong earthquakes with hypocenters very near Nevis occurred in 1951 and 1961. There are encouraging geothermal indicia in at least 5 places on the island so that exploration should be focused and relatively inexpensive. (Huttrer, 1998)

3.4 St. Vincent

La Soufriere volcano has erupted three times since 1902, there is a steaming resurgent dome in the crater, and there are numerous hot springs in the Wallibou River valley on the western side of the volcano. Exploration will be difficult and expensive, however, the discovery of a geothermal reservoir could eventually bring financial rewards as there is a significant and growing demand for power on the island. (Huttrer, 1996)

3.5 Saba

Saba is a small island comprising a central volcano with at least 15 andesitic domes on its flanks. There is a record of volcanic eruption(s) less than 1000 years ago and there are numerous hot springs along the shoreline and just offshore. The island is highly fractured with some hot spring temperatures having risen within the last 45 years. (Huttrer 1998)

3.6 St. Kitts

Though there are moderately large areas of steaming ground in the crater of Mt. Liamuiga, some small thermal springs along the western shore and in the Basseterre Plain, and reports of "scalding" water encountered while drilling for potable water near Brimstone Hill, the geothermal indicia are less well defined than on other islands. Accordingly, exploration will have to be extensive, time consuming, and expensive.(Huttrer, 1998)

3.7 Grenada

Pre-feasibility studies have revealed one small solfatara on Mt. St Katherine, several small thermal springs in ravines radial to the central volcano and numerous young phreatic explosion craters. Additionally, the sub-sea volcano Kick-em-Jenny lies only 5 miles off Grenada's north coast suggesting that the zone between it and central-northeastern Grenada may be geothermally prospective. (Huttrer and Michels, 1993)

3.8 Montserrat

Even before the 1995 eruptions, the southwestern flank of the Sufriere Hills volcano was the site of solfataric activity and of numerous thermal springs. There was also significant seismic activity along the several well developed fracture systems that transect the island. The geothermal potential is obviously very high, but the risk, as would probably be perceived by potential entrepreneurs and lenders, is likely too high to allow geothermal development any time soon.

3.9 St. Eustatius (Statia)

While some heat probably remains beneath The Quill as evidenced by reported occurrences of thermal water in two wells drilled for drinking water, there are no known hot springs or paleo-thermal areas on the island. (Huttrer, 1998).

4. GEOTHERMAL UTILIZATION

There is no utilization of geothermal resources for generation of electricity on any of the nine islands listed above nor are there any geothermal heat pump systems in use. Direct use is limited to "balneolgy" at The Baths on Nevis island, Ravine Claire and Malgretout on St. Lucia, an un-named ravine near Wotten Waven on Dominica, and just outside Peggy's Whim on Grenada. (Quotation marks are used because of the low-technology development style at each site).

4.1 At The Baths, a small (~3 x 3 meters x 1 meter deep) concrete sitting structure has been built adjacent to the Charlestown fault which leaks thermal waters at about 40^{o}C. The waters flow through at rates that depend on the time of year and the abundance or lack of rainfall and there is ~1.5^{o}C temperature change between the entering and leaving waters.

4.2 At Malgretout, water falls from a cliff into a small (3 x 3 x 1 meter deep) concrete sitting pond. The waters overflow into the creek with ~1.5^{o}C inflow-outflow temperature change and at flow rates that depend on the time of year and the climatelogical conditions.

4.3 At Ravine Claire, the un-named ravine near Wotten Waven and at the spring just outside of Peggy's Whim, bamboo pipes stuck into thermal water seeps focus water on shower-takers. Flow rates vary by time of year and drought/rainfall conditions. Inflow-outflow temperature changes are not measurable.

5. DISCUSSION

The figures in Table 1, "Present and Planned Production of Electricity (installed capacity)" differ from those presented in the year 2000 because in this summary 1) the geothermal capacity of the geothermal plant at La Bouillante, Guadeloupe has been left to the French to report and 2) growth of about 18 MW in fossil fuel power capacity has been estimated (no precise figures could be obtained). Please note that there are plans to install at least 20 MW of geothermal power in the region by developers as yet to be identified, and these are reflected in Table 1 projected geothermal totals for 2010.

The entries in Table 3 have been augmented since the 2000 summary by the addition of statistics for the Malgretout springs in Dominica. The true capacity factor for these springs is unknown, but it has been assumed that they flow all year whether used or not.

Table 5 figures reflect those of Table 2 and are self explanatory.

Table 6 reflects the fact that there was no well drilling for geothermal purposes in the English-speaking Caribbean islands in the last 5 years.

Table 7 shows that there was very minimal attention paid to geothermal matters by the governments in all nine countries of interest. The 0.1 person years listed annually is meant to show that it is possible that a few contacts on the subject might have been fielded by officials and some time spent on initial responses.

Finally, Table 8 shows that there was essentially no money spent on Caribbean geothermal project by either the private or public sectors in the last 5 years. It is possible that a few thousand dollars might have been expended by individuals traveling to the region to investigate the geothermal potential, but no projects were initiated from such forays.

6. BARRIERS TO THE INITIATION OF GEOTHERMAL PROJECTS IN THE REGION

There are several reasons why there has been no geothermal project initiation in the region. The first is the very small power demand in these nations, the second is the very high, uneconomical cost of undertaking projects small enough to sell all their power to the local utilities, the third problem is that there are few laws, regulations, or rules in place in these nations that will facilitate the licensing, permitting or creation of geothermal power sales agreements in the islands. Finally, there is little technical or legislative capacity on these islands and whenever some capacity is obtained by one or more responsible government officials, it is soon lost as administrations change and personnel are replaced.

7. FUTURE DEVELOPMENT AND INSTALLATIONS

The barriers described above have been noticed by officials within the Organization of American States (OAS) and they have recently (late 2003) initiated the Geo-Caraïbes Project designed to help the Caribbean region nations overcome these obstacles to geothermal development. The first countries slated to receive assistance are St. Lucia, Dominica and St. Kitts & Nevis. The project will also involve the French Department-islands of Guadeloupe and Martinique.

The essence of this project is for the OAS to use Global Environmental facility (GEF) funds, United Nations Environmental Program (UNEP) assistance, and cooperation with several French Federal and Departmental entities to 1) help build legislative and regulatory capacity in each of the three countries, 2) to provide enough technical (geoscientific) assistance to raise that status of knowledge about the geothermal resources on each island to the point where a “world class”, experienced developer can be enticed to invest in the region and 3) to lessen perceived drilling risks by establishment of a “Drilling Risk Mitigation Fund” whose moneys will be available to qualified developers on a “contingent loan” basis.

A major key to the success of the Geo-Caraïbes Project will be to use geothermal power from Dominica and/or St. Lucia to fill the ~100 MW combined power demands on Guadeloupe and Martinique (by 2012 or so) using sub-sea cable(s) to effect the international power trade. There is a great deal of ground-breaking legal and technical work yet to be done to make this scheme happen, but if it does, it should be a landmark accomplishment that should be replicable in many other archipelagos across the globe.

On a smaller scale, the Project hopes, that with Project assistance, geothermal power can be generated within the St. Kitts & Nevis Federation and then shared via a short (3 km) sub-sea cable. Possibly, in the future, as an extension of such a project, the provision of power to Antigua from the St. Kitts & Nevis Federation might also become a reality.

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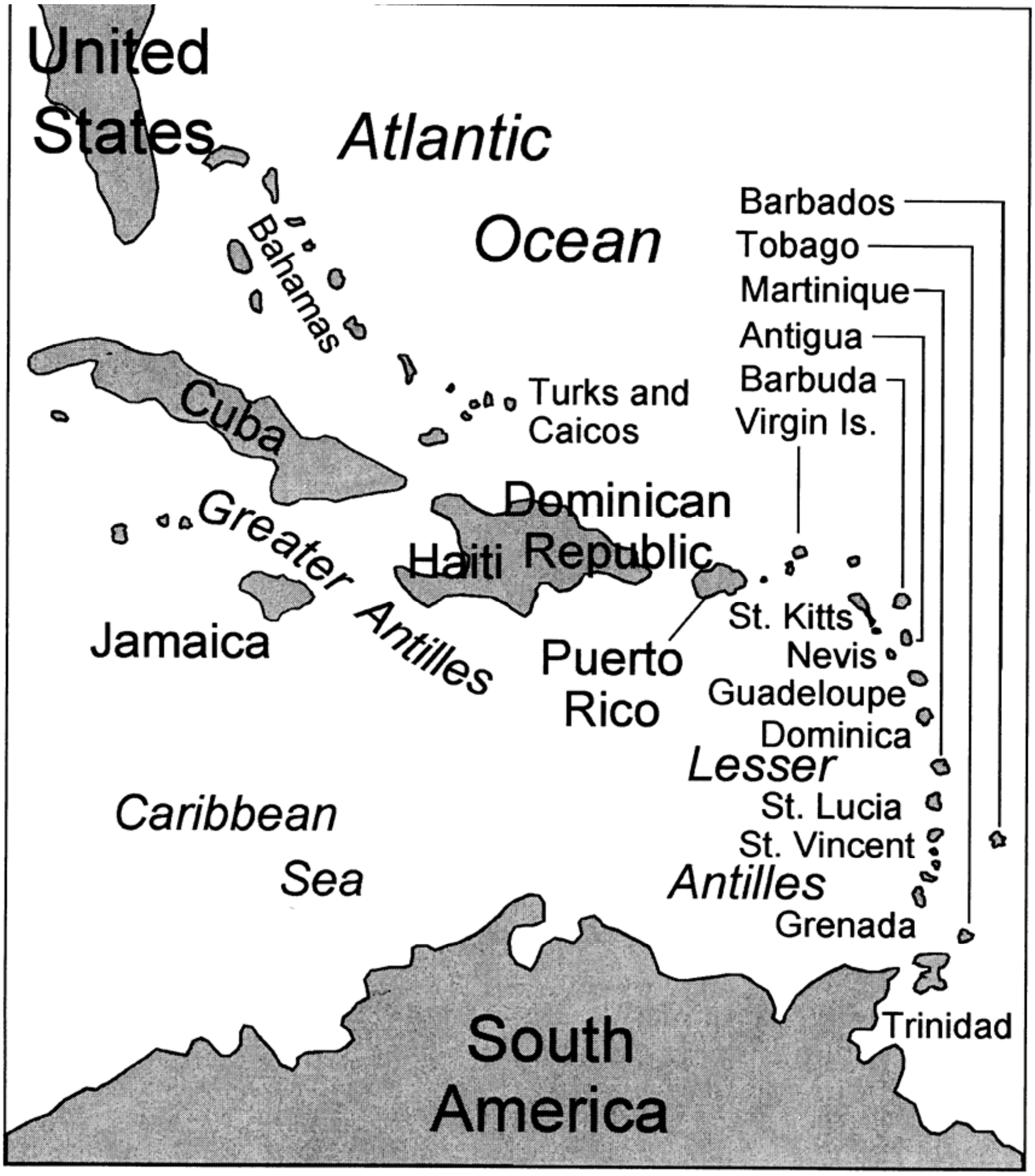

Figure 1 – Location Map

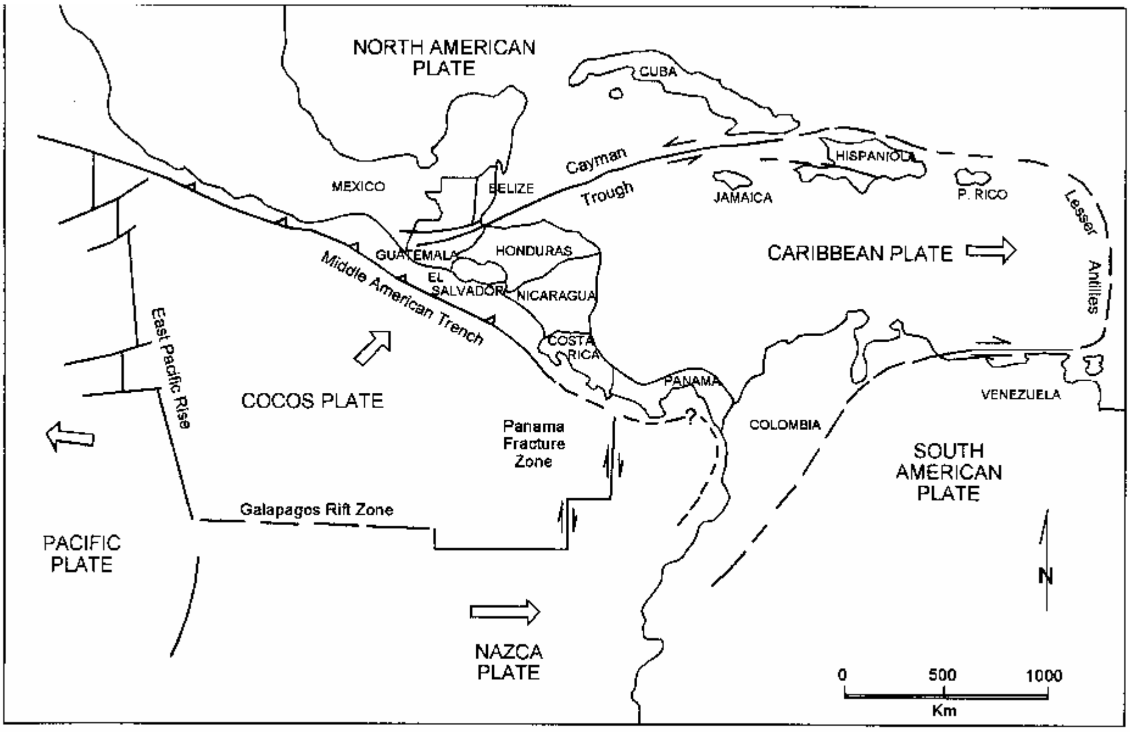

Figure 2 – Crustal Plates of the Caribean Region

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	0		~ 125	~600	9	64.26					~134	~664.26
Under construction in December 2004	0											
Funds committed, but not yet under construction in December 2004	0											
Total projected use by 2010	20	~80	~125	~600	9	64.26					~134	~664.26

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2004

[1] N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

[2] 1F = Single Flash B = Binary (Rankine Cycle)

2F = Double Flash H = Hybrid (explain)

3F = Triple Flash O = Other (please specify)

D = Dry Steam

[3] Data for 2004 if available, otherwise for 2003. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1]	Type of Unit[2]	Total Installed Capacity MWe	Annual Energy Produced 2004[3] GWh/yr	Total under Constr. or Planned MWe
Total								

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2004 (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. (^oC) - outlet temp. (^oC)] 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. (^oC) - outlet temp. (^oC)] 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 (kg/s)	Temperature (^oC) Inlet	Temperature (^oC) Outlet	Enthalpy[2)] (kJ/kg) Inlet	Enthalpy[2)] (kJ/kg) Outlet	(MWt)	Ave. Flow (kg/s)	Energy[4)] (TJ/yr)	Capacity Factor[5)]
Nevis The Baths	B	4.6	43.9	41.5			0.046	3.063	0.969	0.66
Dom. Malgretout	B	6	36	34.5			0.057	9.13	1.806	1
TOTAL		10.6					0.103	12.193	2.775	0.854

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. (^oC) - outlet temp. (^oC)] 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 = 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]			
District Heating [4]			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	0.103	2.775	0.854
Other Uses (specify)			
Subtotal	0.103	2.775	0.854
Geothermal Heat Pumps	0	0	0
TOTAL	0.103	2.775	0.854

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 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 Progran
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000	0.1					
2001	0.1					
2002	0.1					
2003	0.1					
2004	0.1					
Total	0.5	0	0	0	0	0

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) 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$	%	%
1990-1994	0.2					100
1995-1999	0.3				66	34
2000-2004	0				0	0