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Geothermal Energy Resources of India: Past and the Present

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ABSTRACT:

According to India's ambitious energy programme, it appears that Renewable Energy Sources will be generating substantial quantity of power in future. If the geothermal energy potential is exploited, then India will have surplus electrical power. This expansion should be planed to help the rural areas rather than the urban areas. In the very near future India may appear on the geothermal map of the world with the proposal of generating power and direct utilization of geothermal energy from the existing bore-wells in Puga. Utilizing geothermal energy by food processing industries in Himachal Pradesh may make India a global player in future. Potential sites for developing hot dry rock projects do exit in the Himalayas and in central India.

INTRODUCTION:

From the present generation capacity of about 100,000 MWe, India has an ambitious programame of increasing this capacity to about 215,000 MWe by the year 2012 and brings India's power demand to zero. This target is expected from coal, diesel, nuclear and large hydro projects (Abbi, 2001). The renewable energy sources (REs: wind, biomass/bigasse, small hydro) have a potential of generating 54,000 MWe while the installed capacity is 7843 MWe. An additional 1218 MWe is expected to be added in future (MNES, 2003). India's ambition is quite impressive and encouraging since REs can generate half the power demand. These small hydro power stations (SMH: Those that have an installed capacity of 25 MWe) are expected to ease the demand of electric power to rural hill population located within the Himalayas stretching over a length of several kilometers from Kashmir in the west to Arunachal Pradesh in the east (MNES, 2003). Over the last few years large thrust is being laid on the bagasse use in the country. An aggregate capacity of 304 MWe has been commissioned and large incentives are being offered by MNES to promote bagasse programme. This initiative is helping the industries to generate captive power. Major beneficiaries are the sugar industries in States like Maharashtra, which are able to meet its own power requirement as well as supply surplus power to the national power grid. As on date captive (installed) power capacity is 20,000 MWe. If geothermal energy source is tapped, REs will be a major contributor in bridging the gap between demand and supply. The local government of Leh, Ladakh province, has realized geothermal energy potential and taking initiative to develop the Puga geothermal field. The present paper discusses some of the issues related to REs and the scope of developing geothermal energy resources in future.

GEOLOGY AND TECTONIC SETTING:

The seven geothermal provinces in India are located in a wide lithological and tectonic regime varying from a passive continental margin to active subduction related tectonics. The location of these geothermal provinces is shown in figure 1 along with important thermal manifestations. Under a recently completed project supported by government of India and Italy all the thermal waters and thermal gases of India have been sampled and analyzed. Thus a sound geochemical database and geological and tectonic setting of the thermal provinces is now available for future use (Chandrasekharam, 2000; Minissale et al., 2000, 2003;).

West coast:

All the eighteen thermal springs located along the west coast issue through 65 Ma Deccan Flood Basalts (DFB) with temperatures varying from 47 to 72 ^{o}C. The thickness of the basalt flows varies from 2500 to 3000 m along the coast and these lava flows are traversed by a large number of N-S trending faults and dyke swarms (Hooper, 1990). The major tectonic feature along the west coast is the west coast fault, which controls all the thermal springs (Chandrasekharam, 1985, Minissale et al., 2000). The DFB is seismically active with frequent occurrence of low to moderate earthquakes of magnitude 3.5-6.0 (Chadha, 1992). The geothermal gradient recorded from boreholes is about 57 ^{o}C/km (Chandrasekharam, 2000). The lithosphere along this province is about 18 km thick with 1250 ^{o}C isotherm located at shallow depth of 20 km (Pande et al., 1984). Presence of such high thermal regime at shallow depth resulted in high heat flow value (75-129 mW/m^2). The flow rate of the Vajreswari thermal spring (North of Bombay) measured from the natural discharge and bore hole vary from 1 L/s to 7 L /s respectively (Muthuraman, 1986; Chandrasekharam, 2000).

Gujarat and Rajasthan:

The thermal provinces in Gujarat, represented by 22 thermal springs (35-93 ^{o}C) are located in a wide spectrum of lithology ranging in age from Archean to Quaternary with the Cambay basin as its main tectonic structure. The Cambay basin , bounded by two deep seated N-S faults on the east and the west, extending up to mantle depth (Kaila et al., 1981), was formed during the Late Cretaceous and has been rotated anticlockwise during post northward drift of the Indian plate (Biswas, 1987). The 4000m thick sedimentary formation enclosed by the basin is represented by marine and continental claystone, sandstone, conglomerate, fossiliferous limestone and gypsum. This basin contains a few structures containing hydrocarbons, which is being exploited for oil and gas. The Cambay basin is a focus of major alkaline magmatism (Sheth and Chandrsekharam, 1977). Granite intrusives like the 955 Ma old Godhra granite, out crop within the basin near Tuwa where thermal springs with 93 ^{o}C issue (Fig.1). Besides these two major faults bordering the basin, several ENE-

WSW fault systems are present in this basin. Like the west coast, towards the southern part of the basin, the Moho is located at shallow depth, giving rise to a positive gravity anomaly of +35 mgals, high geothermal gradient (70 ^{o}C/km) and high heat flow values (67-93 mW/m^2). Mantle degassing along these deep-seated faults is indicated by relatively high R/R$_A$ ratio of 0.3 and high CO_2 (3%) in the thermal gases (Minissale et al., 2003). A few bore-wells in the Cambay basin yielded steam at depths greater than 1500 m with a discharge rate of 3000 m^3/day (Thussu, 2002). The flow rate of thermal water in certain locations like Dholera and Lasundra is more than 1000 L/s with surface temperature of 46–53 ^{o}C (Minissale et al., 2003).

Archean to Recent lithological formations are exposed in Rajasthan. The entire tectonic regime of NE Rajasthan, which host several thermal springs, has developed over paleo subduction tectonic systems (Sinha Roy et al., 1998). The Great Boundary Fault demarcates the contact between the post and the Precambrian formations, represented by the Vindhyans on the east and the Precambrian formations, represented by the Aravallis on the west. This fault was reactivated during the Eocene due to anticlockwise rotation of the Indian plate and continues to be active at present (Biswas, 1987; Minissale et al., 2003). Several NE-SW trending fault systems, developed due to cyclic and dynamic movement of the blocks, form channels to deep circulating thermal waters. The southern part Rajasthan is covered by fluvial and lacustrine deposit accumulated in the NE-SW trending graben structure developed during the Precambrian (Sinha Roy et al., 1998; Minissale et al., 2003). The surface temperatures of the thermal waters is about 50 ^{o}C

SONATA:

The Son-Narmada-Tapi lineament represented by the Narmada-Tapi rift system, is located between the Indo-Gangetic plain in the north and the Precambrian Shield in the south. The WSW - ENE trending structure that includes SONATA (Fig. 1) is considered to be a mid-continental rift system. This rift system was formed due to the interaction between the two proto-continents (Naqvi et al., 1974) during the early stages of the Indian plate development and reactivated after the collision of the Indian plate with the Eurasian plate (Ravisankar, 1991; Bhattacharji et al., 1994). Deep seismic sounding profiles across the SONATA, south of Tattapani, suggest that the fault system reaches the mantle (Kaila et al., 1985). The Unapdeo and Salbardi thermal springs (Fig. 1) discharge through the Deccan volcanics. In particular, Unapdeo emerges inside the Tapti rift whereas Salbardi falls along the Satpura fault, where DFB are in tectonic contact with the `Gondwana Supergroup' (Dasgupta et al., 1993). The quite famous Tattapani springs (Chandrasekharam and Antu 1995) are located at the eastern edge of the SONATA and are related to the Balarampur fault system. They flow through Archean metamorphic formations consisting of quartzites, schists, gneisses intruded by granites, pegmatites and amphibolites (Joga Rao et al., 1986). The SONATA is a focus of several earthquakes of moderate magnitude and is characterized by high helium (0.54 – 6.89%) and high CO_2 in the thermal gases (2.88%: Minissale et al., 2000). Similarly the Ar content varies from 1.09 to 1.6 %. The surface temperatures of the thermal waters vary from 30 ^{o}C (Salbadri; Fig1.) to 93 ^{o}C (Tattapani; Fig. 1). Both steam and thermal water issues from bore wells at Tattapani with a flow rate of 50 L/s. The entire SONATA has a sedimentary insulation over granite intrusive at about 2 km depth (Chandrasekharam and Prasad, 1998) producing a geothermal gradient of 60 ^{o}C/km. Thus high geothermal gradient at Tattapani (~ 90 ^{o}C/km) as indicated by the high helium content is due to the presence of radioactive minerals in the Precambrian formations at Tattapani). The occurrence of shallow granite intrusive below a thick sedimentary thermal insulation makes this area best suited for initiating hard dry rock projects.

Himalayas:

The Himalayan geothermal provinces, extending over a length of about 1500 km from NW to SE of India host more than 100 geothermal springs, the most prominent ones located within the NW Himalayas (Fig. 2) At Puga both water dominated and steam dominated systems exist (Photos of steam and water). The high heat flow (> 100 mW/m^2) in the entire geothermal provinces is due to the presence of a large number of relatively younger granite intrusives and shallow crustal melting processes (Chandrasekharam, 2001a,b). These granite intrusives lie below a thick sedimentary cover and are under compressive stress regime (Chandrasekharam, 2001) thus making this province most suitable for developing hot dry rock projects. The surface temperatures of the thermal discharges at Chummathang are about 85-87 ^{o}C while at Puga it is 93 ^{o}C. In the Puga valley, more than ten thermal discharges can be seen with the above temperatures (Fig. 3). Individual discharge rate varies from 30 to 40 L/s. Stem discharge is seen very prominently from one of the boreholes drilled by the Geological Survey of India and lies abandoned now (Fig. 4) The entire Puga valley is covered with borax deposits and at places sulphur deposits. The Himalayan geothermal discharges, in general, are saline in nature indicating mixing of saline magmatic fluids (Alam et al., 2004).

GEOTHERMAL RESOURCES AND POTENTIAL:

The Geological Survey of India estimated the geothermal potential of the country to be of the order of 10,000 MWe based on the existing bore holes in some of the geothermal provinces like Puga, Chhumathang, Manikaran in Himalayas and Tattapani and west coast in the Indian peninsular **(Table 1)**. However, for real estimate, the aquifer parameters have to be taken into consideration. The above estimate may be considered as the minimum. Thermal discharges at Puga and Chhumathang were measured in the month of March 2004. The measured discharge from a single borehole is 30-40 L/s at Puga and 15 L/s at Chhumathang. In Puga valley, covering an area of about 10-15 sq.km, there are more than ten such discharge points. If this is taken to consideration, with the surface temperature of 95 ^{o}C the geothermal potential amounts to ~ 5000 MWt. If the cumulative discharges are considered, then the potential would be much higher than that reported. It has already been estimated that the Tattapani geothermal field has potential of 1 MWe. The planned production of electricity through geothermal sources is given in **Table 2.**

Besides power, the Himalayan geothermal energy resources are best suited to support food industries. The lower and middle Himalayan regions experience varied agro-climatic conditions suitable for growing different varieties of fruits like apple, pear, peach, plum, almond, walnut, citrus, mango, raisin grapes etc. The total area under fruit cultivation in Himachal Pradesh (HP) alone is about 2000 km^2 with annual production of about 5000 MT of all kinds of fruits. With an annual growth rate of > 15%, the food processing industries have created investment opportunity worth US$ 30 billions (MFP 2001). By using geothermal energy, India can become one of the world leaders in value added food products (Chandrasekharam, 2001a;

Chandrasekharam and Alam 2003; Chandrasekharam et al., 2003).

GEOTHERMAL UTILIZATION:

But for direct utilization, India is yet to attract independent power producers to utilize this source for power generation. Direct utilization of this energy source is in practice at Manikaran, Vasist in Himachal Pradesh and other provinces where thermal water is used for bathing and therapeutic purposes (Chandrasekharam, 1999). Only at Manikaran, rice is cooked in large copper vessels (Fig. 5) to feed thousands of pilgrims visiting the "Gurudwara', the Sikh's religious shrine (Chandrasekharam and Alam, 2003). Further devotees visiting the Shiva temple near the Gurudwara cook rice in small bags and offer it to the God Shiva. The thermal springs at Vasist (75 ^{o}C) near Manali attract several foreign tourists. Though the geothermal sources at Puga can generate power, in the past attempts were not made to utilize this source. But now, as described below, it is proposed to generate power as well as establish greenhouse cultivation and space heating facilities in Puga valley for the Tibetan residential schools. The thermal discharges from other geothermal provinces like Godavari and Bakreswar are also used for bathing and religious purposes. A detailed description of these thermal discharges can be found in Chandrasekharam (2000 and references therein). Several thermal discharges are being used directly for various purposes **(Tables 3 and 4).**

DISCUSSIONS:

The various power projects and policies undertaken to meet power shortage may benefit the urban elite and help the country to compete in the global market but may not make much difference to the life of 76 million houses located in rural India. Some of the villages in Leh, Ladakh, for example, have not seen electricity even to day in spite of the fact these villages have access to geothermal energy resources. All the stand-alone SMHs may ease the power situation in lower Himalayas but in the middle and the upper Himalayan regions these SMHs will be able to generate power only for three months in a year while the demand is quite large only in winter months. The number of diesel generators used in Leh is so large that the exhaust heat recovered from these generators is able to supply hot water to army hospitals in Leh. Thanks to IITB initiative but this is not going to protect the pristine Leh atmosphere from diesel exhaust. The local government is receptive to geothermal but initiative should come from MNES who grant funds for REs development.

MNES's wrong initiative is delaying the commissioning of Tattapani geothermal field in Madhya Pradesh, which is estimated to generate about 1 MWe. This wrong initiative is in delegating the responsibility of developing Tattapani thermal field to National Hydro-Power Corporation (NHPC). NHPC neither has past experience in handling geothermal power projects nor has the experts in handling geothermal energy exploration projects. Though India has created a strong database on all the thermal discharges of the country (Minissale et al., 2000, 2003), NHPC is unaware of the existence of such geochemical and geophysical database and collaborated with a foreign company for an installed capacity of 1 MWe. Indigenous technology, expertise and manpower are available for generating power. It is not clear whether MNES's ignorance or intention not to encourage geothermal energy resources has killed the project. NHPC's estimate for generating 1 MWe at Tattapani will put the world geothermal exploration companies to shame. Similarly persons involved in coal mining review geothermal proposals submitted for MNES funding!

FUTURE DEVELOPMENT AND INSTALLATIONS:

The number of professionals trained in developing geothermal resources and investment made in developing geothermal energy resources is far less (**Tables 5 and 6**). In the near future geothermal resources at Puga and Chhumathang will be developed for power generation and for direct use. The temperatures of the Chumathang and Puga geothermal discharges are at boiling point of water (87- 93 ^{o}C) and greater than 3 kg/cm^{2} steam discharge can be seen from some of the old bore-wells in Puga valley (Fig. 4).

The air temperature in Leh varies from 30 °C to 35 °C in summer and in winter it is -30° C. The Stakna hydro power station with an installed capacity of 2 MWe and 13 MWe of power generated from diesel generators are the main source of electricity for the rural Leh population. In fact, a majority of villages in this district, as stated above, have not seen electric power even today. Kerosene lamps for light and wood and charcoal for heating the houses are in use even today. During winter, the Stakna hydro power station ceases to generate power due to snow cover and freezing of water and only diesel generators are the main source of power. Power interruptions are quite common during winter. Since diesel is air-lifted from Delhi and Chandigarh, the cost of government subsidized power is around 14 US cents per kWh. With out the government subsidy the cost will escalates to over 28 cents. According to the Chief Executive Councilor of The Hill Development Council of Ladakh, the present power demand of Leh is around 59 MWe and this demand is expected to grow to 94 MWe in the year 2010. The construction of several SMHs is not going to bridge the gap between demand and supply since hydro power stations idle during winter months when the demand for power is maximum. The Chief Executive Councilor of Ladakh opined that generating power from the existing geothermal sources might ease the situation to certain extent especially during winter seasons. As shown in the tables appended, greater than 5000 MWt is available at Puga, which can be utilized for heating and creating greenhouse cultivation. Green house cultivation is required since all the vegetables are flown either from Delhi or from Chandigarh and the army is supplying vegetables to the rural Leh population at affordable cost. It is most surprising and pathetic to see the Tibetan residential school children located within the Puga valley live without electricity and all the children brave the cold temperatures (~ -20 ^{o}C) in winter months. Solar photovoltaic power supply is a ray of hope at present for these children in Puga valley. These systems may not lost longer than 2 years due to inherent problems associated with maintenance and low success rates of photovoltaic system in general (World Bank, 1999).

Realizing the potential of geothermal energy in Leh, a project has been initiated jointly by IITB, The Hill Development Council of Ladakh, Ladakh ecological Development Group (LeDEG) and Ladakh Renewable Energy Development Agency. Under this initiative, the thermal discharges from the existing bore-wells in Puga valley alone will be developed in two phases. During the first phase two HPs, each capable of recovering 50-75 kWt of heat for space heating, water heating, greenhouse cultivation and ice-melting applications will be developed and deployed. During the second phase the 50-75 KWt heat pipes will be integrated with sealed turbo-generators for co-generating about 10-15 kWe and ~ 75 kWt of heat for space heating applications (say at 20-35 ^{o}C). The entire

Puga valley geothermal resources will thus be utilized for supporting a number of Tibetan residential schools. These schools will be self sufficient with respect to power, space heating and vegetables. Once successful, similar systems will be installed at Chhumathang. Similarly the steam discharge (Photo) will also be utilized directly for generating power in Puga valley.

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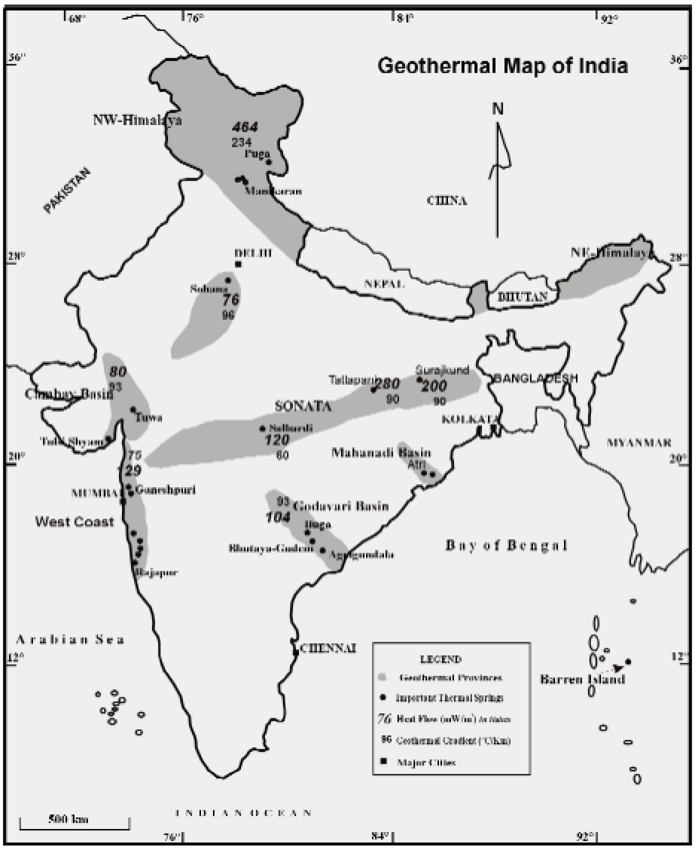

Figure1. Map showing the geothermal provinces of India

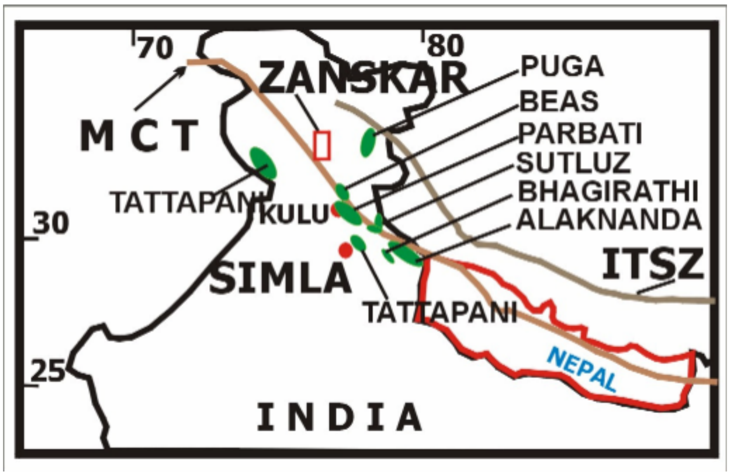

Figure 2. Map showing the geothermal provinces of NW Himalayas

Figure 3. Hot water jet from a bore-well in Puga

Figure 4. Steam jet from a bore-well in Puga

Figure 5. Rice being cooked at Manikaran "Gurudwara"

TABLE 1. 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)	31		73		0.2-0.6
Production	>150° C					
	150-100° C					
	<100° C					
Injection	(all)					
Total		31		73		0.2-0.6

TABLE 2. 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	Nil	Nil	72174	222801	25116	84223	2720	8200	7843	4492	107853	319716
Under construction in December 2004	Nil	Nil	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Funds committed, but not yet under construction in December 2004	100	500##	73741	187057	32673	202677	9380	53279	1218	3851	117112	447364
Total projected use by 2010	100	500	145915	409858	57789	286900	12100	61479	9061	8343	224965	767080

Decrease in Fossil fuel is due to India signing Kyoto Protocol in future
Only wind energy may add substatially to REs
ND: data not available
##: tentetive

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. (^{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 Flow Rate (kg/s)	nperature (^{o}C) Inlet	Outlet	Enthalpy[2)] (kJ/kg) Inlet	Outlet	Capacity[3)] (MWt)	Annual Utilization Ave. Flow (kg/s)	Energy[4)] (TJ/yr)	Capacity Factor[5)]
Himalayas	B,O	400[a]	95	15			134	35	369.32	0.087
Cambay	B	100[b]	85	25			25	15	118.71	0.15
West coast	B	100[c]	72	30			22	10	68.59	0.098
SONATA	B	100[d]	95	25			18	100	923.3	1
Bakreswar(W.Ben	B	15[e]	66	30			2	15	71.22	1
Godavari	B	15[e]	58	30			2	15	55.39	0.925
TOTAL										

O: Cooking
a: cumulative discharge of 10 springs
b: cumulative discharge of 10 springs
c: cumulative discharge of 16 springs
d: discharge from two bore wells
e: single spring

TABLE 4. 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]	203	1606.53	0.251
Other Uses (specify)			
Subtotal	203	1606.53	0.251
Geothermal Heat Pumps			
TOTAL	203	1606.53	0.251

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

TABLE 5. 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	2		10		4	
2001	2		12		4	
2002	2		12		4	
2003	2		12		4	
2004	2		12		4	
Total	10		58		20	

TABLE 6. 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	ND	ND	ND	ND		
1995-1999	0.022	Nil	0.00816			100
2000-2004	0.031	Nil	0.0122			100

ND: Data not available