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Geothermal Energy Update of Nepal

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ABSTRACT

After a silence of three decades, the government of Nepal made a modest beginning to launch geothermal programme in 2001 by updating the profile of few geothermal locations that are popular and accessible. This was in recognition of the role of geothermal energy reflected in the Ninth Plan (1996-2001). The ever-increasing political and economic crisis in Nepal over the past 8 years caused serious impact on the continuity of this energy sub-sector as well. The Alternate Energy Promotion Center under the Ministry of Science and Technology vows to exploit geo-thermal energy in the future. Definite programmes on geothermal energy are yet to emerge in the current Tenth Plan (2002-2007). Some noteworthy efforts are undertaken by the local geothermal management committees with the financial support of the rural people in upgrading the physical infrastructures in some geothermal locations. This has created positive feedback effect by attracting more people and thus, increasing revenues for the physical expansion through local resources.

Since most geothermal areas are located in the northern and remote regions of Nepal, geothermal exploitation is not regarded economically viable at the moment because of the heavy investment associated with the construction of roads. Nepal witnessed a very encouraging development in road construction during the geothermal update period 2001-2005. The expansion of south–north road network is expected to produce a dramatic positive result in the future geothermal energy. Added to this is the planned opening of more trade ports at the border between Nepal and the Tibetan autonomous region of China by the year 2005. This will directly boost the use of some more thermal locations. Apart from the ongoing popularization activities in the direct use of geothermal energy in Nepal, it is highly desirable that pilot projects in some potential locations are initiated in order to attract the private as well as the public sector

1. INTRODUCTION

Nepal, home to Mount Everest, is dominated by the world's most imposing mountains. Even though the country is relatively small (147,181 square kilometers), 80 percent of its territory is occupied by the dramatic peaks of the Himalayas**.** Nepal can be divided into three geographical regions: Mountains, Middle Hills and the Terai. The Terai area (the southernmost strip of land) is now completely converted to agriculture production and serves as the breadbasket of Nepal.

Nepal's population is about 23.8 million, located primarily in the Terai and Hilly regions. The Mountain area is sparsely populated, with little vegetation above the tree-line (4,200 meters).

1.1 Government Setting

King is the head of the State and the Prime Minister heads a Council of Ministers appointed from the elected House of Representatives and the National Assembly. On November 1990, a new constitution was promulgated which introduced a multi-party system and established King as a Constitutional Monarch. However, since the last three years, the King has been exercising full executive power in the absence of the House of Representatives.

The legislature is bicameral: National Assembly with 60 members, of whom 35 are elected by the House of Representatives, ten appointed by the King and 15 are elected on a regional basis; House of Representatives with 205 elected members from national single-member constituencies. Supreme Court acts as court of appeal and review as well as having powers of original jurisdiction; presides over 4 regional, 15 zonal and 75 district courts. The country is divided into 5 Development regions, 14 zones, 75 districts, 3995 village development committees and 36 municipalities

1.2 Policies and Interests

The State Policies as elucidated in the Constitution of Nepal (1990) are to: raise the standard of living of the general public through the development of infrastructures, strengthen the national unity, mobilize the natural resources and heritage, protect the environment by increasing the awareness of the general public, achieve economic progress by raising productivity in the agro-industrial sector, increase the participation of labour force in the management of enterprises, activate females in development works, promote the interests of the economically and socially backward groups and communities, develop science and technology, attract foreign capital and technology by simultaneously promoting indigenous investment, and institutionalize peace through international recognition

In line with these long term policies, the current Tenth Plan of Nepal (2002-2007) has focused on poverty alleviation by improving economic, human and social indicators through the expansion of economic and employment opportunities and the proper mobilization of resources in joint participation with government, local bodies, private sector and civic society; and by enhancing the access of women, down-trodden people living in rural areas.

The major strategies of the Plan are to control population and maintain good governance, promote economic opportunities through high, sustainable and broad-based economic growth, and create appropriate bases for the distribution of their opportunities to various sectors and classes, enhance the capability and mainstreaming of the down-trodden and backward communities, strengthen women's empowerment through the expansion of investment in social services, empower them in the decision-making process of different programmes, and stress on self-employment, income-generating and security-enhancing programs.

The following four aspects will be focused in the implementation of these strategies.

1. **Achieve** high, sustainable and broad-based economic growth by defining the role of local bodies, private sector, and maximize the development of agriculture, forestry, industry and water resources sectors;

2. **Emphasize** the development of infrastructures and social sector;

3. **Launch** targeted and empowerment programmes to create bases for a respectful life of the weak, helpless, disabled, and elder citizens of the society and for promoting the interest of the disadvantaged, oppressed, down-trodden and ethnic classes;

4. **Emphasize** participatory economic development through the mobilization of local resources, and promote the efficiency and credibility of local bodies through the implementation of decentralization process.

Priority will be given to the increased use of technology, enhancing productivity and efficiency, and management of population. Women empowerment and their mainstreaming have been identified as nucleus in the implementation of the strategy for poverty alleviation.

<u>1.2.1 Alternate and Rural Energy Policies and Priorities</u>

The Tenth Plan (2002-2007) aims to develop and expand alternative energy as a powerful tool for alleviating poverty, raise the purchasing power of the rural people by developing alternative energy technologies based on local resources, increase the consumption of alternative energy and reduce dependency on imported energy through the proper utilization of local resources.

The Plan aims to give priority to the activities that are carried out in an integrated way so as to help the economic, social and environmental sustainability while developing and expanding alternative energy.

While the Plan has formulated specific programmes for mini hydroelectricity, biogas, improved cook stoves, and solar energy, no such programmes exist for geothermal energy. The general programmes for all energy subsectors include feasibility study, research and development, promotion, exhibition and awareness, decentralized energy management, and demonstration of model projects.

Encouraged by the high success in the past, the Plan has continued to set up a Rural Energy Fund to increase the access of poor, deprived and minority communities to alternative energy through group collateral scheme, rolling fund and release of loans at low interest rates.

For rural energy development, the Plan intends to improve pricing policy, link alternative energy technology with rural development programme, promote proven technologies, implement area based energy development programmes, promote alternative energy technology in the areas with no national electricity grid, establish energy park, extend financially viable energy technologies to different areas, involve non-governmental organizations, international non-governmental organizations and private agencies in alternate energy development, and reduce fire wood consumption.

<u>1.2.2 Potential Agencies in Geothermal Energy</u>

At present, no lead agencies for geothermal activities are existent in Nepal. The potential agencies include the Ministry of Science and Technology, Research Center for Applied Science and Technology (Tribhuvan University) and the Department of Mines and Geology. The Alternate Energy Promotion Centre (AEPC) under the Ministry of Science and Technology has embraced geothermal energy among other renewable energy resources such as biomass, micro-hydro, solar, wind, and improved cook stoves. AEPC does not directly implement renewable energy projects but works with the Renewable Energy industries and Non-Governmental Organizations to provide decentralized renewable energy services to rural as well as urban communities.

2. GEOLOGICAL SETTING

Nepal can be distinctively divided into six geological zones.

Terai: The Terai is the Nepalese portion of the Indo-Gangetic Plain that extends from the Indian Shield in the South to the Siwalik Fold Belt to the North. The plain is a few hundred metres above sea level and usually 400 to 600 m thick. It is composed of Recent Quaternary alluvium, boulder, gravel, silt and clay. Terai Plain is underlain by a thick, relatively flat-lying sequence of Mid to Late Tertiary molasses (Siwalik Group) which uncomfortably overlies subbasins of early Tertiary to Protorozoic sediments, igneous and metamorphic rocks of the Indian Shield.

Sub-Himalaya (Siwaliks): The Sub Himalayan Zone or the Siwaliks of Nepal extends throughout country from east to west in the southern part. It is delineated by the Himalayan Frontal Thrust (HFT) and Main Boundary Thrust (MBT) in south and north respectively. The Siwaliks consist of very thick (4000 to 6000m) molasses-like fluvial sedimentary deposits comprising a coarsening-upwards sequence as a whole.

This zone is the 10 to 25 km wide belt of Neogene Siwaliks (or Churia) Group rocks, that forms the topographic front of the Himalaya. It rises from the fluvial plains of the active foreland basin, and this front generally mapped as the trace of the Main Frontal Thrust (MFT). The Siwalik Group consists of upward coarsening successions of fluvial mudstone, siltstone, sandstone, and conglomerate.

Lesser Himalaya: The Lesser Himalaya lies between the Sub-Himalayas and Higher Himalayas separated by MBT and the Main Central Thrust (MCT) respectively. The total width ranges from 60-80 km. The Lesser Himalaya is made up mostly of the unfossiliferous sedimentary and meta-sedimentary rocks. The geology is complicated due to folding, faulting and thrusting and these complications added by the unfossiliferous nature. The northernmost boundary of the Siwaliks Group is marked by the Main Boundary Thrust (MBT), over which the low-grade metasedimentary rocks of the Lesser Himalaya overlie. The Lesser Himalaya is a thick (about 7 km) section of para-autochtonous crystalline rocks comprising low- to medium grade rocks. The Lesser Himalaya thrust over the Siwaliks along the MBT to the south.

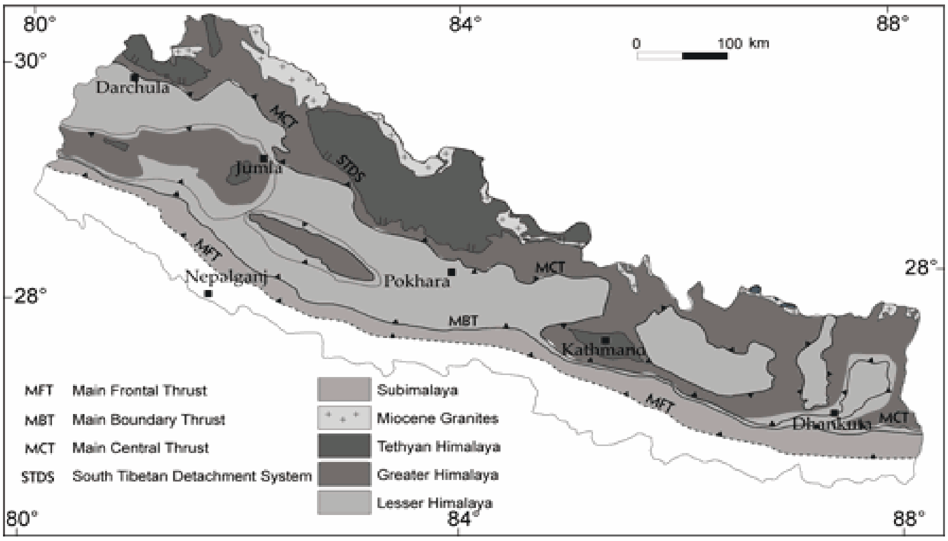

Figure 1: Geological Map of Nepal

Main Central Thrust Zone: The Main Central Thrust (MCT) is the single largest structure within the Indian plate that has accommodated Indian-Asian convergence. It extends for nearly 2500 km along strike and has been the site of at least 140 and perhaps more than 600 km of displacement. The metamorphic grade within the Lesser Himalaya increases towards the MCT and at higher structural levels. The highest-grade rocks (kyanite and sillimanite gneisses) are found within the MCT shear zone i.e. upper Lesser Himalaya.

Higher Himalaya: This zone extends from the MCT to Tibetan-Tethys Zone and runs throughout the country. This zone consists of almost 10 km thick succession of the crystalline rocks, commonly called the Himal Group. This sequence can be divided into four main units, as Kyanite-Sillimanite gneiss, Pyroxenic marble and gneiss, Banded gneiss, and Augen gneiss in ascending order.

The High Himalayas are mainly composed of kyanite- to sillimanite-grade gneisses intruded by High Himalayan leucogranites at structurally higher level. Throughout much of the range, the unit is divided into three formations. In central Nepal, the upper Formation III consists of augen orthogneisses, whereas the Middle Formation II are calcsilicate gneisses and marbles, and the basal Formation I are kyanite- and sillimanite bearing metapelites, gneisses, and metagreywackes with abundant quartzite.

Tibetan-Tethys: The Tibetan-Tethys Himalayas generally begins from the top of the Higher Himalayan Zone and extends to the north in Tibet. In Nepal, these fossiliferous rocks are well developed in Thak Khola (Mustang), Manang and Dolpa area. This zone is about 40 km wide and composed of fossiliferous sedimentary rocks such as shale, sandstone and limestone etc.

The area north of the Annapurna and Manaslu ranges in central Nepal consists of metasediments that overlie the Higher Himalayan zone along the South Tibetan Detachment system. It has undergone very little metamorphism except at its base where it is close to the Higher Himalayan crystalline rocks.

3. GEOTHERMAL RESOURCES AND POTENTIALS

3.1 Geothermal Resources

In Nepal, geothermal manifestations occur in about thirty localities (Fig. 2) that are mostly confined to three distinct tectonic and structural features. The first group is located beyond the Higher Himalayas and north of the Main Central Thrust (MCT), which itself is situated between the units of the Lower and Higher Himalayas. The second group of thermal springs lies close to the MCT while the third group falls on the Main Boundary Fault (MBF). The MBF developed as a result of the collision of the Indian Plate with the Eurasian Plate. A complete profile of all the geothermal localities of Nepal is yet to be prepared and updated since more springs are reported in new localities. A description of some of the available thermal springs follows.

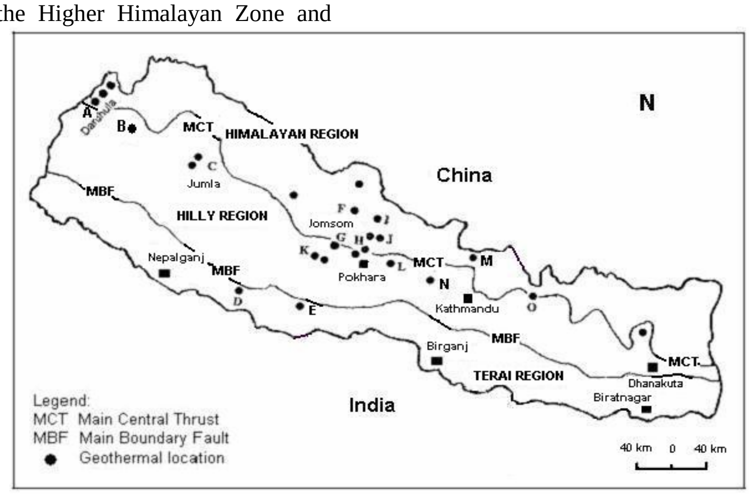

Figure 2, Location of Geothermal Springs

The Darchula district in the Far Western Region has three thermal springs located at Sina, Sribagar and Chamaliya. The Sina thermal springs occur in crystalline rocks located near the thrust contact between the overlying augen gneiss and the underlying sericitic schist and quartzite. The thrust is displaced by a recent fault on which many springs are aligned. The hot springs in Sribagar rise from the recent river sediments and are located near the tectonic contact between the autochthonous metasedimentary zone of Baitadi-Bajhang and the crystalline sheet. The tectonic contact is marked by the highly crushed chlorite-sericite-quartz phyllites on the ridge east of Sribagar. The Chamaliya spring issues from the recent terrace deposit and is confined to a metasedimentary autochthonous zone composed of slates and carbonate rocks. The thermal springs in Bajhang district are near the major thrust between the crystalline allochthonous and metasedimentary autochthonous zones. The purple shale and green sandstone with gritty quartzites are highly folded. The major thermal source is located near the thrust zone whereas the minor sources are either near some fault or the contact zone of different lithological units.

In Jumla district, the thermal springs occur mainly in Tila Nadi and Dhanchauri. A vertical geological section along Tila Nadi is shown in Figure 3. The right bank of Tila Nadi accommodates a number of closely located hot springs. Gas seepage occurs in some of them in recent deposits of gravel and boulders with sandy-silty clay. Mini-folds and micro-faults can be observed along the Tila Nadi valley indicating the neotectonic activity. Two seepages occur at the fracture joints in the calcareous gneiss and marble. The geological map of Jumla district is given in Figure 4.

In Dhanchauri area the spring issues from the light-grey platy dolomite and is characterized by a thick tuffaceous deposit consisting of carbonate and silica. Three major hot springs are located here.

Riar thermal spring is located at the south of the Siwalik formation (a northern chain of hills reaching a height of some 1500 m) and the rock in the immediate vicinity is covered by soil. The Mayangdi spring issues from the base of a cliff of poorly cemented Quaternary conglomerates. An extensive fault passes through it, and carbonaceous and schist and siltstone are

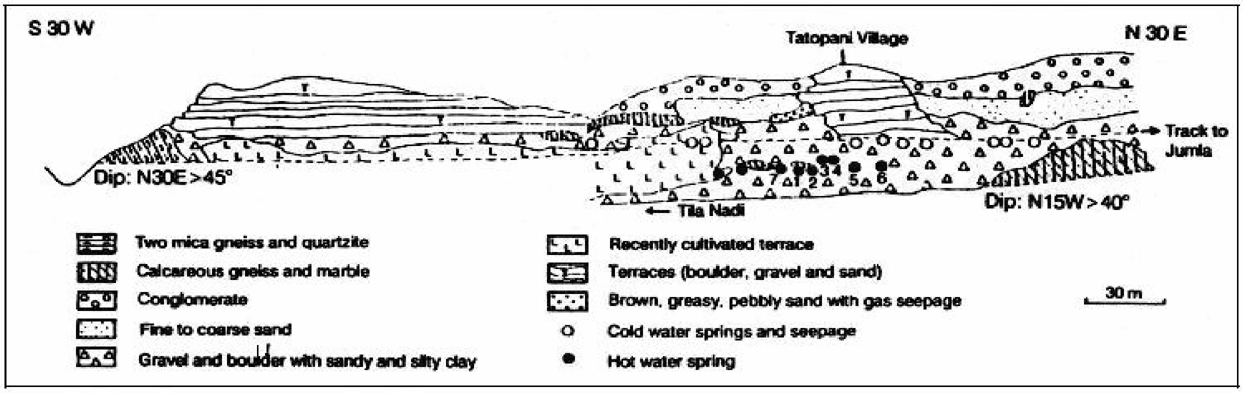

Figure 2: A Vertical Geological Section Along Tila Nadi

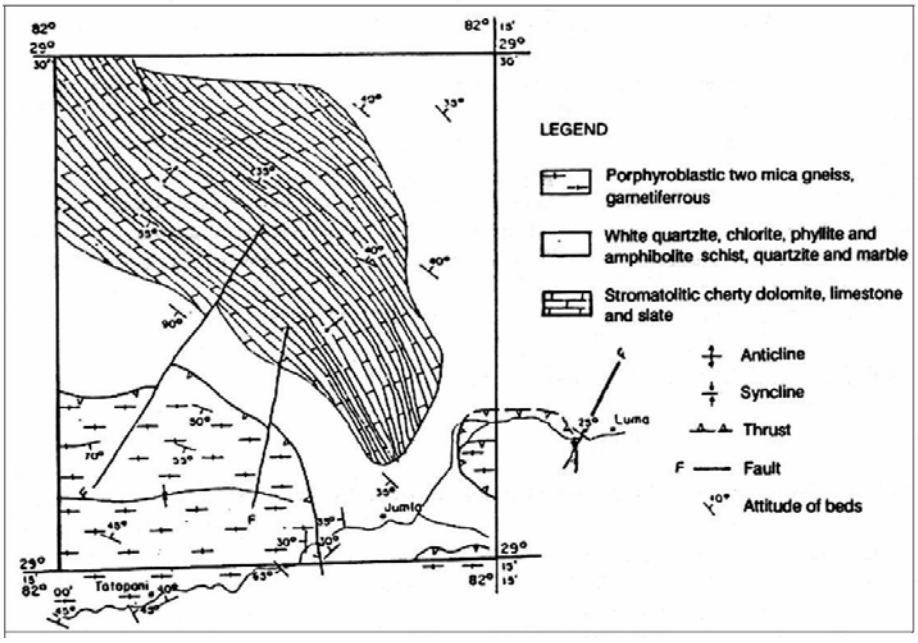

Figure 3: Geological Map of Jumla

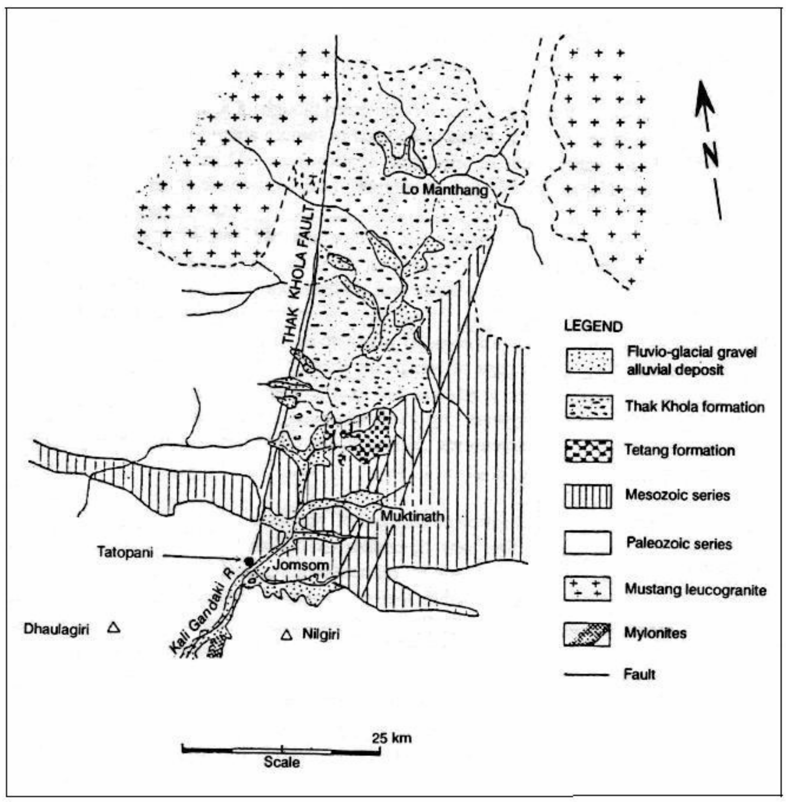

Figure 5: Geological map of the Thak Khola - Mustang area

exposed on both sides of the fault. There are four springs in this locality. The rock in the area surrounding Surai Khola thermal spring is sandstone, siltstone and clay, belonging to the middle Siwalik. There are two discharge points in this area.

The springs in the Thak Khola – Mustang area are located at the foot of a berm about 100 m high on the bank of the Kali Gandaki River. The geological map of this area including Jomsom (headquarter of Mustang district) is shown in Figure 5. Five springs are located here. However, the flow rates are extremely low and all the springs are issuing from a single source. Some other prominent geothermal springs in the Western Region are Bhurung Tatopani, Dokhola, Singha Tatopani (Myagdi district), Chhumrung and Dhadkharka (Parbat district), Dhee and Lo-Manthang (Mustang district), Chame (Manang district), Bhulbhule Khar (Lamjung district) and Khar Pani (Kaski district). One more thermal spring has been reported at the bank of a river near Darbang in the Myagdi District. No further information is available.

Unlike many other springs that occur along the river banks, the spring in Chilime issues on the top of a cliff. The surrounding bedrock of this thermal spring consists of quartz, biotite sandstone, graphitic argillaceous schist and siliceous limestone. In Syabru Besi, two springs can be noted in the river bank. One of them has been extensively used by the trekkers and the local hotel businessmen for cooking purposes. In the Kodari area, hot water issues at several points. The surrounding bedrock is of quartz biotite sandstone overlain by slightly graphitic argillaceous schist and underlain by siliceous limestone. The physical infrastructure of the spring area is under improvement despite continuous land slides. Only one thermal spring has been identified in the eastern part of Nepal. Even though this spring at Hatiya (Sankhuwasabha district) is popular among local community and the access road made more comfortable to attract increased number of visitors, no geochemical studies have been made so far.

3.2 Geothermal Potential and Progress

The updated chemical data of the thermal springs are given in Table 1. Sribagar records the maximum surface temperature (with 73.4°C) among the thermal waters in Nepal. This is followed by 71°C in Bhurung Tatopani at Myagdi district. Temperatures above 40° C were recorded for six other springs.

Table 2 lists the results of the chemical analyses for some thermal springs. Studies from the available chemical data show that the most springs waters in Nepal have extensive interaction with rock at comparatively low temperatures. The spring waters of Jomsom, Sadhu Khola, Bhurung Tatopani, Chilime, Sribagar, Dhanchauri and Tila Nadi are in equilibrium and all the other springs waters are unsaturated with the most common hydrothermal alteration minerals. The spring waters at Bhurung Tatopani and Sadhu Khola are chloride waters (relatively mature), and those of Jomsom, Dhanchauri-Luma, Mayangdi, Surai Khola and Chilime are representative of the waters with high CO_2 reactivity. Somewhat detailed chemical analyses of thermal springs including isotopic composition indicate that a large geothermal reservoir exists in the western Nepal. There also exists a good opportunity to exploit this energy resource for various direct uses in this region because of the comparatively good terrain and possibility of future road network development.

One of the notable achievements in the geothermal update period is that the government has prepared ‘Alternative Energy Perspective Plan’ (2002-2017) which recognizes geothermal energy as one of the alternate source of energy for Nepal. The plan includes updating the geothermal data; undertake feasibility studies for direct heat use, and popularization activities. After a long silence of more than three decades, the government of Nepal initiated geothermal programmes in 2001. The Alternative Energy Promotion Centre sponsored field surveys of two popular and accessible geothermal locations (Kodari and Singha Tatopani). However, the study limited to undertaking preliminary chemical analysis of thermal water. General information of other thermal springs has been updated with the author's personal initiative.

During the period, some activities were conducted to inform the journalists about the importance of geothermal energy and the various direct uses of low temperature waters. Such information was also provided through national television programmes and popular articles. Through the later activities, significant increase of visitors has been observed in many thermal areas, notably at Singha Tatopani, Bhurung Tatopani and Kodari Tatopani. The Singh Tatopani management, in particular, has prompted other thermal locations to adopt the approach. As a result, many Tatopani (thermal spring) Development Committees have been formed at the initiative of the local youths and development workers. The village development committees were also encouraged to improve/develop the physical infrastructure of the local thermal areas. This has attracted more visitors from the surrounding places. The net effect is an increase in the revenue generated from the users. A large proportion of such revenue went back for the expansion of physical facilities, thus causing a positive feedback effect. For the first time, there has been direct investment of the village committee's fund particularly for the development of thermal areas. This is indeed a very encouraging example. Usually this fund comes from the government as a package program to meet the minimum needs of the village, e.g. road construction, expansion of health facilities etc.

The speedy turnover of people towards geothermal locations has been limited to bathing activities alone. Considerable attention has been paid to make the spring areas environmentally sound with proper management of toilets and minimizing the use of solid wastes in the vicinity. This sort of awareness is growing rapidly in areas where the number of visitors are increasing. No other environmental laws, legislations or policies exist at any level in exploiting geothermal resource in Nepal because its development is still at the grass root level.

Table 1: Geothermal Localities and General Information

Locality	Symbol	Location		Flow rate	Surface Temp.	Geothermometer temp. (°C)			Ionic balance diff.	Discharge enthalpy
		Lati. (E)	Long. (N)	(l/s)	(°C)	SiO_2	Chalcedony	Na/K ratio	(%)	(kJ/kg)
Darchula	A									
Sribagar		80.6°	29.9°	0.9	73	85.1				380
Sina Tatopani		80.7°	29.9°	0.8	30					255
Chamaliya		80.6°	29.7°	0.3	30	37.6				158
Tapoban	B	81.2°	29.6°	0.3	31	55.1				126
Jumla	C									
Dhanchauri-Luma		82.3°	29.3°	0.8	24	106.9		88.2		448
Tilanadi		82.1°	29.2°	1.3	42	110.6			-34.3	464
Riar	D	82.7°	27.9°	1.5	33		54.2	52.3		227
Surai Khola	E	83.3°	27.8°	1.7	36		50.1	100.4	4.8	210
Jomsom	F	83.7°	29.8°	3	22	50.3			1.61	211
Bhurung Tatopani	G	83.7°	28.5°	1.8	72	115.4			-0.19	484
Sadhu Khola	H	84.2°	28.4°	1.5	68	109.8		115.3	4.52	460
Kharpani	I	84.1°	28.4°	0.4	49					
Mayangdi	J	83.5°	28.4°	2	40	89.8			-21.03	376
Singha Tatopani	K	83.3°	28.2°	6	54	91				452
Bhulbhule Khar	L	84.2°	28.2°	1.2	34					
Chilime	M	85.3°	28.3°	0.9	48	98.8				386
Syabru Besi	N	85.2°	28.1°	0.4	34	86.5	55			365
Kodari	O	83.9°	27.9°	5.5	42	96.5				17

Table 2: Chemical composition of some thermal spring waters of Nepal

Location	pH	Na	K	Mg	Ca	Cl	SO_4	HCO_3	SiO_2	B	TDS
Bhurung Tatopani	7	370	95	27	108	583	207	370	71	14.1	1650
Jomsom	8	60	5.6	54	113	96	249	302	14.3	2.4	850
Tila Nadi	7.3	56	0	1.2	6	45	130	0	60	0	353
Dhanchauri-Luma	7	49	1.3	0.2	6.1	82	104	217	56	0	803
Mayangdi	8	460	49	17	2	351	68	430	43	0.3	1340
Riar	9	310	4	3	4	14	70	7.9	37.5	6	788
Surai Khola	9	123	3.9	28	18	3.2	70	370	38.5	0.1	510
Sribagar	7	100	11	8.5	n.a.	34.2	18.5	n.a.	35	0	516
Chamliya	7	n.a.	n.a.	n.a.	n.a.	39.6	10.7	n.a.	10	n.a.	1320
Tapoban-Bajhang	6	n.a.	22	10	n.a.	50.1	25.9	n.a.	16	0	444
Sadhu Khola	7	300	12	0.6	10	286	197	78	60	0	954
Chilime	7	7.35	8.1	20.8	25.8	10	6	180	47.1	0	166
Singha Tatopani	7.2	64	1.5	1.8	6.8	51	140	10	68	0	353
Syabru Besi 1	8	73	44	84	38	66	94	848	59.7	n.a.	620
Syabru Besi 2	7.5	7.2	12.5	90.5	75.9	12	121.4	760	35.3	n.a.	1300
Kodari	7.3	147	29.7	20.5	53.5	31.5	85.6	412.5	44.3	1.36	n.a.

Evidently, the low temperature nature of the spring waters is not technically and economically viable for the generation of electricity in Nepal. Nepal's electricity generation heavily relies on hydro power - nearly 91% of the nation's power comes from this source. Nepal currently has a surplus of 600 million units of electricity and is at a stage to sell a large portion of it to neighboring countries. The country's huge hydropower potential seems to overshadow any other forms of energy sources for electricity. The government is busy in preparing ambitious hydropower projects. However, its exploitation heavily depends on the foreign loan and assistance. Frequent interruption of fund, political bargaining for the sale of large scale power produced, effect of climate change on the frequency and intensity of flooding and droughts, greater unreliability of dry season flows, difficulty in predicting runoff patterns etc. are posing serious threat in its exploitation. This implies that Nepal will have to seek for alternative sources of power generation, including from fossil fuel sources. At present, the interrupted electricity supply has forced many industries to use fossil fuel to generate electricity.

The use of geothermal water in Nepal is still constrained by the lack of road network. The update period witnessed the opening of two trade ports in the mountainous districts viz. Kimathanka and Chid (Sankhuwasabha district) and Nechung and Lizi (Mustang district) bordering China. These ports will soon yield greater access to the adjacent geothermal areas. The on-going construction of north-south highways (Surkhet-Jumla, Baitadi-Darchula, and Baglung-Jomsom) will play significant role in connecting a number of geothermal springs upon their completion.

The concept of using low temperature water for purposes other than bathing cannot be realized in Nepal without some pilot scale demonstration projects. The efforts from the government side cannot be expected in the foreseeable future because it is experiencing difficulty to continue the ongoing development projects owing to continued insurgency over the past 8 years, forcing the government to cut down its development budget and increase military budget. The Tenth Plan of Nepal aims to set up Rural Energy Fund at the district and village levels to integrate alternate energy with economic development activities. However, the Fund is largely expected to be donor-driven (88 %). The rising political and domestic economic crises have led its implementation to a stand still. Current development in biogas, mini hydroelectric generation, improved cook stove, solar energy projects are all the results of foreign technical and financial assistance made available at the initial stage. Little progress thus achieved was able to attract the government's attention to search for more investment. Therefore, even if the Fund is at place, geothermal subsector will have to strongly compete with other operational energy programmes in which a number of national and international non-governmental agencies are involved, and have developed manpower as well as demonstration capability at different levels.

In such a situation, the lead international agencies advocating geothermal development should at least come forward to play a catalytic role to initiate some direct utilization projects in geothermal energy from its ground level.

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Table 3: 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		74	337.07	553	2321.5	0		0.2	0.911	627.2	2659.5
Under construction in December 2004	0		0		10	45.55	0		0.12	0.5466	10.12	46.1
Funds committed, but not yet under construction in December 2004	0		0		70	318.85	0		0	0	70	318.9
Total projected use by 2010	0		91	414.505	993	4523.115	0		0.2	0.911	1084.2	4938.5

Table 4: Utilization of geothermal energy for direct heat (as of 31 December 2004)

B = Bathing and swimming (including balneology)

Locality	Type	Maximum Utilization					Capacity	Annual Utilization		
		Flow Rate (kg/s)	Temp. (°C) Inlet	Temp. (°C) Outlet	Enthalpy (kJ/kg) Inlet	Enthalpy (kJ/kg) Outlet	(MWt)	Ave. Flow (kg/s)	Energy (TJ/yr)	Capacity Factor
Singh Tatopani	B	6	54	30			0.602	4.5	14.245	0.750
Bhurung Tatopani	B	1.8	72	28			0.331	1.3	7.545	0.722
Kodari	B	5.5	42	30			0.276	4.6	7.281	0.836
Mayangdi	B	2	40	31			0.075	1.6	1.899	0.800
Bhulbhule Khar	B	1.2	34	28			0.030	1	0.791	0.833
Sadhu Khola	B	1.5	68	34			0.213	1.1	4.933	0.733
Chilime	B	0.9	48	35			0.049	0.7	1.200	0.778
Sribagar	B	0.9	73	30			0.162	0.7	3.970	0.778
Chameliya	B	0.3	30	25			0.006	0.3	0.198	1.000
Tapoban	B	0.3	31	30			0.001	0.3	0.040	1.000
Dhanchauri	B	0.8	24	23			0.003	0.7	0.092	0.875
Tilanadi	B	1.3	42	35			0.038	1.2	1.108	0.923
Riar	B	1.5	33	25			0.050	1.3	1.372	0.866
Surai Khola	B	1.7	36	26			0.071	1.5	1.979	0.882
Jomsom	B	3	22	17			0.063	2.6	1.715	0.866
Kharpani	B	0.4	49	30			0.032	0.4	1.002	1.000
Syabru Besi	B	0.4	34	28			0.010	0.35	0.277	0.875
Others	B	1.5	36	25			0.069	1.2	1.741	0.800
TOTAL							2.084		51.388	0.782

Table 5: Summary Table of geothermal direct heat uses

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr = 10^{12} J/yr)	Capacity Factor
Individual Space Heating	0		
District Heating	0		
Air Conditioning (Cooling)	0		
Greenhouse Heating	0		
Fish Farming	0		
Animal Farming	0		
Agricultural Drying	0		
Industrial Process Heat	0		
Snow Melting	0		
Bathing and Swimming	2.084	51.388	0.782
Geothermal Heat Pumps	0		
TOTAL	2.084	51.388	0.782

Table 6: Allocation of professional to geothermal activities

(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)
2000			2			
2001			5			
2002			5			
2003			2			
2004			2			
Total			16			

Table 7: Total investments in geothermal in 2004 (US$)

Period	Research & Development including surface exploration & exploration drilling Million US$	Field development including production drilling & surface equipment Million US$	Utilization		Funding Type	
			Direct* Million US$	Electrical Million US$	Private %	Public %
1990-1994	0	0	0.007	0	100	0
1995-1999	0	0	0.007	0	100	0
2000-2004	0	0	0.01	0	94	6

* ESTIMATED