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Geothermal Energy Update of Nepal

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ABSTRACT

Six new geothermal areas have been identified in Nepal during the update period. Of these, the thermal spring in Hatiyana (Sankhuwasabha district) is the first one ever identified in the eastern part of Nepal. Other four are located in La Ta Manang (2400 m in Manang district, Western Nepal), and DanaTatopani (1190 m in Myagdi district, northern–central Nepal) along the famous Annapurna trekking circuit, Dhadkhark (Myagdi district), and Dhima in Mustang district. The thermal location at Dana Tatopani issues water as high as 67°C. Scientific studies about these springs are still lacking.

Nepal's energy scenario has not changed significantly during the update period. The country still depends heavily on firewood for energy needs while continuing to focus more on hydroelectricity generation. Nepal launched a five year National Rural Energy Programme (NRREP) in 2012 which mainly intends to provide subsidy rather than conducting any research and development (R&D) activities. It has encompassed wind energy for the first time. Amidst the political crisis, a number of international agencies are instrumental to help utilize renewable energy sources like biomass, solar energy, and improved cook stoves to some extent during the update period. However, geothermal energy has still remained the neglected area, due largely to the lack of road access to geothermal areas, trained and motivated manpower, financial resource, economic viability of utilizing geothermal energy for electricity generation and lack of knowledge about its direct use.

However, at the local level, dramatic developments have taken place in some geothermal fields like Singa Tatopani, Darmija Tatopani and Ghorepani Tatopani – all located in Myagdi district. With local efforts, infrastructural development and management of geothermal field have taken place in a significant way in Singa Tatopani. It has also contributed to tourism development and improving health conditions of the rural people. This site can be cited as a model for the geothermal development of workers willing to do something on their own. District Development Committees in other geothermal areas have been active to improve the physical infrastructure.

With the expansion of North-South Highways and completion of Lok Marg (Highway) that runs through mid-hill region linking the east – west border of the country, the prospect of harnessing geothermal energy has increased tremendously. There exists a good scope for the local entrepreneurs and international community to invest money in the direct utilization of this energy resource, conducting geophysical-chemical studies, and developing infrastructure that promotes tourism in a number of geothermal areas. Central part of Nepal is the area where the study shows the existence of a large geothermal area suitable for harnessing it.

1. INTRODUCTION

Nepal is located between China on the north and India on the east, west and south (Fig. 1). It lies between latitudes 26° and 31°N, and longitudes 80° and 89°E. The south to north elevation ranges from 90 to 8,848 meters within an average breadth of 193 km. The High Himalayas stand in the northern belt. Along its southern border is the flat and fertile Terai region. The central hills have terraced cultivation and swiftly flowing mountainous rivers. Eight of the world's highest peaks including Mount Everest (8,848 m) are located in Nepal. The country's official size is 147,181 km2 which is constantly shrinking due to land encroachment by the friendly neighbour, India.

Figure 1: Map of Nepal

The country has a projected population of 28,191 million in September 2014 and the population growth rate stands at 1.35 percent (World Population Review 2014). There exists a very balanced sex distribution (male 49.6% and female 50.4%) as reported by CountryMeters (http://countrymeters.info/en/Nepal). About 7.3 percent of this population lives in the mountains, 44.2 percent in the hills and 48.5 percent in the southern flat Terai.

1.1 Government Settings

Nepal is currently passing through a period of political transition. In 2006, a jumbo constituent assembly of 601 members was formed to write a new constitution and restructure the state. However, it failed to agree on a constitution despite two extension periods within 4 years. A second election for a new constituent assembly of the same size took place in December 2013 and political leaders are still able to assure the people that a final constitution will be in place by January 2015 which is very unlikely. The new constitution, if at all, is expected to come up with a federal structure of governance.

The President acts as the Head of the State and the Prime Minister assumes the executive power. Nepal's political power is increasingly controlled by India, taking advantage of the morality of country's political leaders. Currently, the Constituent Assembly is functioning both as the legislature parliament representing the Upper and the Lower Houses. In the absence of a clear majority of any political party in the Assembly, coalition governments are running the country. It will continue to do so during the update period and far beyond.

Supreme Court acts as court of appeal. The country is divided into 5 Development regions, 14 Zones, 75 Districts, 3,995 village development committees and 36 municipalities.

1.2 Policies and Interests

Amidst growing political instability, Nepal could develop only a short and interim three year plan (2010-2013) – the second in a row. Its two major objectives are to alleviate poverty and establish sustainable peace through the employment centric inclusive and justifiable economic growth. This Plan also constitutes a part of the ambitious long term goal to upgrade the country from its current status of Least Developed Country to Developing Country by the year 2022 (Interim Plan, NPC, 2010-2013).

Under a similar political instability, the country had to adapt another three year interim plan (2013-2016). Its major priority areas include development of the energy sector, commercialization of agriculture, improvement in basic education, health, drinking water and sanitation, good governance, expansion of roadways, development of physical infrastructures, tourism and trade. The plan aims to attain an average 6 percent economic growth annually over the period. The plan will also attempt to decrease the poverty rate to 18 percent from the current 23.8 percent (Interim Plan, NPC, 2013-2016).

1.3 Lead Agencies Involved in Geothermal Energy

Some of the agencies that may be eligible to become lead agencies in geothermal activities are:

i. Research Centre for Applied Science and Technology (RECAST), Tribhuvan University;

ii. Department of Mines and Geology, Ministry of Industry; and

iii. Alternate Energy Promotion Centre (AEPC), National Planning Commission

However, these agencies are not active for the lack of financial resources and manpower to conduct geothermal activities. The first two agencies can serve as research and development institutions while the third can take initiative in conducting pilot studies and installation of geo heat pumps for demonstration purpose.

2. GEOLOGY BACKGROUND

Nepal can be divided into five distinct morpho-geotectonic zones from south to the north (Fig. 2). The southernmost fault, the Main Frontal Thrust (MFT) separates the Sub-Himalayan (Siwalik) from Gangetic Plains. The Main Boundary Thrust (MBT) separates the Lesser Himalayan Zone from Siwalik whereas the Main Central Thrust (MCT) separates the Higher Himalayan Zone from the Lesser Himalayan Zone.

i. Gangetic Plain (Terai Zone): Considered as a bread basket, the Terai is a rich and fertile land in the southern part of Nepal. It is the Nepalese extension of the Indo-Gangetic Plains. The plain is less than 200 meters above sea level. This zone forms a nearly continuous belt from east to west. To the north, this zone is separated by an active thrust system called as the Main Frontal Thrust (MFT) with Siwalik. Northern Terai (Bhabar Zone) acts as a recharge zone for the groundwater of Terai. Middle Terai Zone is a narrow zone of about 10-12 km wide. Southern Terai Zone is the southernmost part of Terai up to Nepal-India border and also continues into India. This zone consists of main sediments of Gangetic Plain.

ii. Sub-Himalayan (Siwalik) Zone: This zone is delimited on the south by the Main Frontal Thrust (MFT) and on the north by the Main Boundary Thrust (MBT). It extends all along the Himalaya forming the southernmost hill range with width of 8 to 50 km. The Lesser Himalayan rocks thrust southward over the rocks of Siwalik along the MBT.

iii. Lesser Himalayan Zone (Mahabharat Range and Valleys): This zone is bounded to the north by the Main Central Thrust (MCT) and to the south by Main Boundary Thrust (MBT). MBT can be traced out in the entire Nepal Himalaya. From east to west, the Lesser Himalayan Zone of Nepal varies in rock type, age, structures, and igneous rock intrusion.

iv. The Higher Himalayan Zone: This Zone mainly consists of huge pile of strongly metamorphosed rocks. It includes the rocks lying north of the Main Central Thrust (MCT) and below the highly fossiliferous Tibetan-Tethys Zone. It consists of an approximately 10 km thick succession of strongly metamorphosed coarse grained rocks extending continuously along the entire length of the country. Granites are found in the upper part of the unit.

v. Inner Himalayas (Tibetan-Tethys) Zone: The Zone begins from the top of the South Tibetan Detachment System and extends to the north in Tibet. Most of the Great Himalayan peaks of Nepal such as Manaslu, Annapurna, and Dhaulagiri have rocks of Tibetan-Tethys Zone.

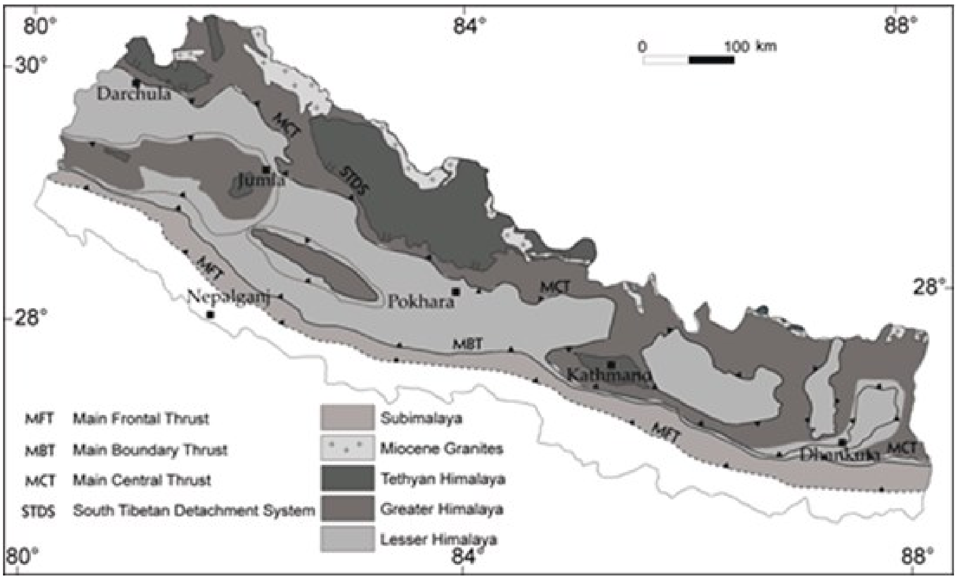

Figure 2: Geological Map of Nepal

3. RENEWABLE ENERGY IN NEPAL

Despite Nepal's potential wealth in solar energy and hydropower (the highest after Brazil) and three decades of research, development of these energies has not kept pace with population growth. The little renewable energy that has been harnessed is poorly distributed. The ratios of traditional, commercial and renewable energy consumption stood at 79.87 percent, 18.48 percent and 1.66 percent respectively in the year 2013. Traditional energy sources are distributed at firewood for cooking (71.26%), agricultural residues (3.52%), and livestock residues (5.09%). In the commercial sources, petroleum shared 11.78%, coal 4.14% and electricity 2.56% (Economic Survey of Nepal, 2014).

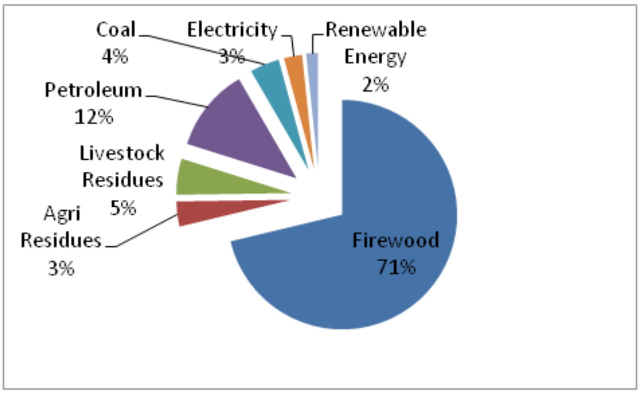

Figure 3: Renewable Energy Use Pattern, 2013 (Economic Survey, 2014)

The World Energy Outlook's Energy Development Index, which measures household electricity provision, ranked Nepal near the bottom of countries in 2012. Despite the gradual improvement made in electricity access over the past two decades, less than 30% of rural household and 53.64% of the country's Village Development Committees are connected to the national grid. Urban dwellers can face power-cut of 14-16 hours a day. Only about 12 percent of the country's population uses electricity derived from water, wind or sun. In November 2010, Nepal intended to invest in renewable energy services, particularly solar and wind, as a means to grow the citizens' often badly-needed energy access and leapfrog into climate-friendly development, with support from the Scaling up Renewable Energy Program in Low Income Countries (SREP) under the Climate Investment Funds (www.climateinvestmentfunds.org).

In 2011, the country's first mini wind-solar hybrid power system was installed in Nawalparasi district with technical and financial support from the Asian Development Bank. The hybrid system was installed as a pilot project based on the energy systems planning approach and has installed two sets of 5 kW wind turbines complemented by a 2 kW peak solar photovoltaic panel to satisfy the village's daily electricity demand of 43.6 kW hours. So far, none of the agencies has attempted any geothermal related installations.

In 2012, Nepal launched a five year framework called National Rural and Renewable Energy Programme (NRREP). In 2013, the country adopted a policy of subsidizing renewable energy, the latest of many attempts to electrify long-deprived areas. More than half of the country's households, almost all in urban and semi-urban areas, are connected to the national electricity grid. But 80 percent of the population is rural, and in these areas, less than one-third have electricity. With grid extension to the country's hilly and mountainous areas prohibitively expensive, officials are looking to off-grid renewable alternatives. The new policy funds technologies sourced from hydropower, solar, biogas and for the first time wind. The policy also seeks to use biomass, a traditional energy source, more efficiently.

Such technology is almost entirely absent in the most inaccessible and deprived regions, like the country's western Karnali Zone, where over 80 percent of the people have moderate or serious problems getting enough food. The new subsidy policy emphasizes reaching women and the "socially excluded" with targeted subsidies.

In February 2014, Nepal White Power Pvt. Ltd. and Hubicon Company Pvt. Ltd. of South Korea signed a Memorandum of Understanding to generate 49 MWe of electricity from solar energy at Kavresthali (Kathmandu) and Sangla Village Development Committee by installing more than 163 thousand solar panels. So far, the promotion, development and installation of various renewable energy technologies are undertaken by the government with support from donor agencies and partners. These efforts are limited to providing energy for rural communities for cooking and lightening purpose. Recently, the entrepreneurs seem to be ready to invest in innovative energy production and expand the use of renewable energy to industrial units.

3.1 Geothermal Energy in Nepal

Evidently, out of the three most neglected renewable sectors namely, solar, wind and geothermal solar energy is gaining momentum while wind energy is at the doorstep again. However, geothermal energy still remains out of focus mainly due to the lack of initiative to demonstrate its direct utilization (in agricultural drying, fish farming, greenhouse heating, snow-melting, biodigestion etc. in the Nepalese context), less feasibility of harnessing this source for electricity, lack of access to geothermal areas, lack of trained/motivated manpower and many other factors. The newly reported thermal springs during the update period are:

i. Ghorepani Tatopani located at 28° 29' 33.4824" N, 83° 39' 5.0256" E in the famous Annapurna trekking circuit in the Western Nepal (http://wikitravel.org/en/Annapurna_Circuit)

ii. Dhadkharka in Myagdi district

iii. Darmija Tatopani, Myagdi district along the Darmija River

iv. Dhima in Mustang district

v. La Ta in Manang district

vi. Hatia in Sankhuwasabha, Koshi zone, Eastern Nepal.

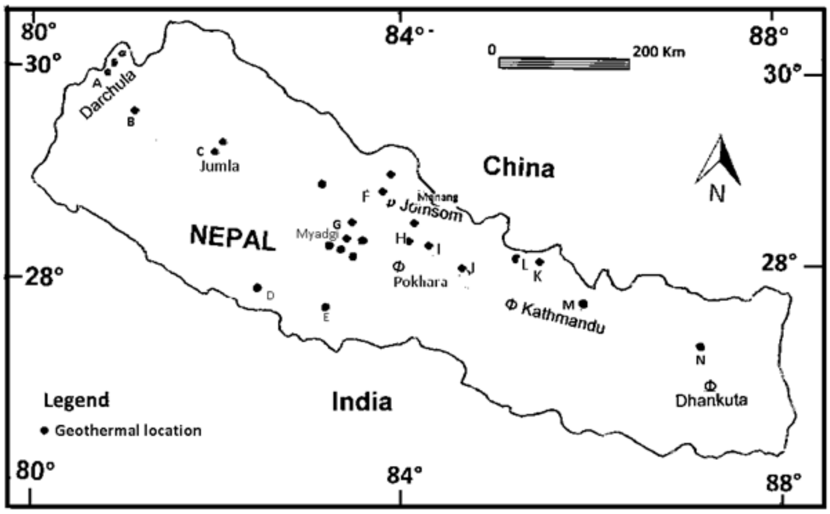

Fig. 4: Location of geothermal springs in Nepal

Of all the hot springs in Nepal, the most popular one is the Singa Tatopani located at 2,743 m.a.s.l. (latitude 28^{o}N and longitude 82.7°E) in Myagdi district. It is about 390 km west of Kathmandu and 150 km from Pokhara. The spring pool has a of dimension 11.0 m X 5.8 m X 0.62 m and can hold up to 100 people at a time. More than 60,000 people from various parts of the country visit this spring every year mainly to cure for rheumatic and gastric diseases (Photos 1, 2 and 3). Some participate for recreation.

Fifteen years ago, there existed only an open pond in a desperate situation even though quite a number of people from the surrounding area used to visit it during winter season. Popular articles and photos were published in different leading daily newspapers. The national Nepal Television team visited this pool and Kodari geothermal area, the documentary was televised from time to time during the winter season for a couple of years. It attracted the people from various remote areas as well. This inspired the local community to improve the physical infrastructure (e.g. roof installation, toilets, change rooms, ticket counters, and information depot etc.) in and around thermal area. During the winter season, bathing in the pond takes place 18 hours a day with alternating shift of three hours for male and female. The Tatopani (hot water) Committee raises moderate fee from the incoming visitors which is utilized for expanding facilities with additional financial support from local village development committee. Generally, people from the remote areas visit the thermal area for a month, with necessary foods for their entire stay. A number of people also enjoy local hotels, restaurants and lodges in and around thermal area. Local business expanded, folk songs focusing on the local thermal spring were composed and sung, adding thrills to the visitors while they take the bath. This can be viewed as 'myagdi, singa tatopani' in the 'youtube'. The old temple has been replaced by the new one where people pray for Hindu Goddess and sacrifice animals to cure for diseases.

Photo 1: People entering pool at Singa Tatopani.

Photo 2: Singa Tatopani pool

Photo 3: Tourists in Tatopani in Annapurna Circuit.

Photo 4: Sulphur- rich water fountain in Chilime

Employment opportunities have been provided to local people to collect and manage fund while the road to the thermal area has been constructed and expanded. This area has provided an excellent example to show how the local people can help boost up the use of thermal water for balneotherapy by mobilizing local resources.

Interaction and competition among people from the adjoining thermal areas have taken place for its best utilization and management of thermal water. For instance, in Darmija hot spring (located on the bank of Raghuganga River in Myagdi district) a shelter has been constructed to accommodate 200 visitors and the committee vows to develop the thermal pond as a tourist destination. The local village development committee has protected the pond from the river by constructing a wall (Himalayan Times, 2011).

With the increased number of tourists along the famous Annapurna Circuit, the Ghorepani Tatopani and Bhurung Dana Tatopani has expanded the physical facilities to extend the tourists' stay (Photo 3). In a number of adjoining geothermal localities, people have started to exert pressure to the local village committees to expand facilities and build separate pools for the females.

The next popular thermal area is the Kodari Tatopani located on the bank of Bhotekoshi River at Kodari in Sindhupalchowk district near the border between Nepal and China. It is about 114 km away from Kathmandu valley. It stands at latitude of 27.9^{o}N and longitude of 83.9^{o}E. Thousands of people from Kathmandu and surrounding area visit this place for bath and recreation. No pools have been made yet due to its location on the river bank with the possibility of being washed away from a landslide and the swelling river. However, the structure is more convenient for showering as a number of spouts have been installed.

In terms of geothermal well drilling, Nepalese land is still virgin. No drilling activity has taken place for production or exploratory purpose. No investment has been made in the research and development (R&D) activities including surface exploration and exploratory drilling. Investment is limited to improving and extending physical facilities at the geothermal pools funded by local people and development committees. Even though a number of geologists, chemists, geochemists, geophysicists and engineers are available in the country, they are not geared towards geothermal activities at the moment. The little manpower trained in the geothermal area are either outdated or unavailable.

4. IS GEOTHERMAL ENERGY AN OPTION FOR NEPAL?

High political instability in the country for more than a decade has affected the formulation and implementation of long-term plans and policies, including geothermal. As a result, the country is moving slowly towards generating energy to meet the growing needs. Availability of a huge hydroelectric potential will continue to overshadow the government's focus for the utilization of other renewable energy resources for many years to come. However, the slow implementation and inability to complete any of the ongoing large scale hydroelectric projects on time have been a great concern. As a result, very recently, the local entrepreneurs have shown a keen interest to invest in alternate sources of energy to meet their immediate industrial energy need. The government also has shown some interest to utilize solar energy in its main administrative headquarters and lighting capital streets. A few non-governmental organizations have emerged to display various renewable sources of energy in some parts of the country.

However, geothermal energy has still remained the neglected area for a number of reasons. Trained manpower is outdated and no new manpower generation has taken place for more than a decade. Motivated manpower is lacking. Energy officials have a lack of knowledge about its direct uses. Until last decade, the road network was not good or non-existent to conduct geophysical and other studies as well as to conduct direct use projects. There was no possibility to expect high investment from the entrepreneurs in constructing roads for geothermal purpose alone. Economic viability of utilizing geothermal energy for electricity generation is still questionable. The much-awaited joint Glitnir Bank and Noida geothermal project, set to start in the country in 2010 could not materialize due to the world economic crisis that hit Glitnir Bank of Iceland. This has almost ended the hope of harnessing electricity through geothermal fluid in the north-western parts of Nepal for the time being. Nonetheless, the prospect for the use of geothermal energy development is becoming eminent in the country for a number of reasons:

i. Awareness has risen among the local people to mobilize local financial and physical resources for development activities (e.g. expansion of facilities including road in the Singa hot spring area.)

ii. Local entrepreneurs are now in a position to consider geothermal energy as a viable option if they have knowledge about the direct uses of it.

iii. Conducive atmosphere has been developed recently for the investors and scientific explorers with the opening of the 170 km long Lok Marg (Middle Hills Highway). It runs from Panchthar district in the far east to Baitadi district in the far west. The fundamental difference between Lok Marg and the old East - West Highway lies in the fact that Lok Marg runs through the middle hilly areas connecting 23 districts and provides easy access to many geothermal locations. (Fig. 5).

iv. The North-South highway connecting Myagdi and Jomsom is already open. The Karnali Highway connecting Surkhet and Jumla is another significant development. Investors need not spend money for having resources and conduct scientific / feasibility studies. It was considered one of the major bottlenecks for geothermal development in Nepal. With the expansion of north-south highways, the need to use the available low temperature geothermal water for snow melting at higher altitude is becoming more obvious.

v. Road access has opened yet another possibility to explore the use of granites available in the northern central and western area. Hopes for High Density Rock (HDR) technology has increased to tap it for small scale electricity generation in the much energy deprived northern areas, even though it may not be economically feasible with geothermal fluid under the currently available technologies. Central Nepal is the area where the preliminary study shows the existence of large geothermal reservoir (Ranjit, 2010). This is also the area where the North-South and East-West (Lok Marg) Highway is operational.

Fig. 5: Mid Hills Lok Highway running East West

5. DISCUSSION AND CONCLUSION

Table 1 points out that a number of geothermal locations still lack chemical analysis data even though in some localities, part of information is available. The available data are not up to date. No recent efforts are made towards this direction even though it is not a limiting factor. Development workers / entrepreneurs like to rely on the most recent data.

Table 1: General information about localities and temperature

Locality	Symbol	Flow Rate (l/s)	Surface Temp (°C)	Discharge Enthalpy (kJ/Kg)
Darchula	A			
Sribagar		0.9	73	380
Sina Tatopani		0.8	30	255
Chamaliya		0.3	30	158
Tapoban	B	0.3	31	126
Jumla	C			
Dhanchauri – Luma		0.8	24	448
Tilanadi		1.3	42	464
Riar	D	1.5	33	227
Surai Khola	E	1.7	36	210
Mustang	F			
Muktinath		3	22	211
Jomsom		0.07	16.5	380
Dhima		n.a.	n.a	n.a
Myagdi Disrict	G			
Ghorepani Tatopani		n.a.	n.a	n.a
Singa Tatopani		6	54	452
Dhadkharka		n.a	n.a	n.a
Chhumrung		n.a	n.a	n.a
Darmija		n.a	n.a	n.a
Dana Bhurung		1.8	72	484
Mirsa – Seti Khola area		n.a.	n.a.	332
Jamile		0.05	30.6	n.a.
Kharpani	H	0.4	49	n.a
Machhapuchhre base camp		2.2	64	1020
Mayangdi	I	2	40	376
Down Batase		0.1	44.3	420
Up Batase		0.2	21.5	n.a.
Bhulbhulekhar	J	1.2	34	n.a.
Rasuwa	K			
Chilime		0.9	48	386
Syabri Besi		0.4	34	365
La Ta Manang	L	n.a.	n.a.	n.a.
Pargang		3.8	49	390
Kodari	M	5.5	42	17
Hatiya- Sankhuwasabha	N	n.a	n.a	n.a

Table updated after Ranjit, M., WGC Proceedings and WGC Proceedings Technical Paper (2010). Symbols A, B, C ….N refer to location of thermal springs in the map of Nepal (Fig. 4 in the text).

Table 2 and 3 indicate that Nepal uses this energy resource solely for balneotherapy and tourism purposes. Currently, Nepal has an installed capacity of 3.3 MWt, and around 81 TJ of geothermal fluids are utilized of which more than 90% are for balneotherapy, recreation and tourism. In a number of localities, water with surface temperature alone is enough for conducting projects like biodigestion, agricultural drying, and greenhouse heating purposes. People have no idea about how to utilize it.

Table 2: Utilization of geothermal energy for direct heat (as of December 2014)

Locality	Type	Maximum Utilization			Capacity	Annual Utilization		
		Flow Rate (kg/s)	Temperature ©		(MWt)	Average Flow	Energy	Capacity
			Inlet	Outlet		(kg/s)	(TJ/yr)	Factor
Darchula								
Sribagar	B	0.9	73	35	0.143	0.8	4.01	0.889
Sina Tatopani	B	0.8	30	25	0.017	0.7	0.462	0.875
Chamaliya	B	0.3	30	25	0.006	0.3	0.198	1.000
Tapoban	B	0.3	31	24	0.009	0.3	0.277	1.000
Jumla								
Dhanchauri–Luma	B	0.8	24	18	0.02	0.7	0.554	0.875
Tilanadi	B	1.3	42	34	0.044	1.1	1.161	0.846
Riar	B	1.5	33	25	0.05	1.3	1.372	0.866
Surai Khola	B	1.7	36	26	0.071	1.4	1.847	0.823
Muktinath	B	3	22	15	0.088	2.7	2.493	0.900
Jomsom	B	0.07	16.5	12	0.001	0.05	0.03	0.714
Bhurung Tatopani	B	1.8	72	30	0.316	1.3	7.202	0.722
Sadhu Khola	B	1.5	68	30	0.238	1.2	6.015	0.800
Jamile	B	0.05	30.6		0.006	0.04	0.161	0.800
Kharpani	B	0.4	49	30	0.032	0.3	0.752	0.750
Machhapuchhre base camp	B	2.2	64	31	0.304	2	8.705	0.909
Mayangdi	B	2	40	30	0.084	1.7	2.242	0.850
Down Batase	B	0.1	44.3	26	0.008	0.1	0.241	1.000
Up Batase	B	0.2	21.5	15	0.005	0.2	0.171	1.000
Singha Tatopani	B	6	54	30	0.602	5.6	17.727	0.933
Darmija	B	5.1	50	29	o.6	2.52	8.6	0.02
Bhulbhulekhar	B	1.2	34	27	0.035	1	0.923	0.833
Chilime	B	0.9	48	35	0.049	0.8	1.372	0.889
Syabri Besi	B	0.4	34	28	0.01	0.3	0.237	0.750
Pargang	B	3.8	49	30	0.302	3	7.518	0.789
Kodari	B	5.5	42	30	0.276	5.1	8.072	0.927
TOTAL					3.316		81.112	0.88

(Type B in the table refers to use for Bathing and Swimming including balneology). Table updated after Ranjit, M., WGC Proceedings (2010).

Economic Survey of Nepal (2014) figures the current production of electricity at 746 MWe. The country will see a sudden rise in production after the completion of ongoing large scale projects within a few years. Interim Plan of Nepal (2013-2016) indicates that construction of various projects totaling 1,252 MWe are underway, out of which 668 MWe is estimated to be produced by the beginning of 2015 (Table 4). This will further undermine the utilization of alternate energy sources for electricity generation. Geothermal energy will remain the most neglected source for electricity generation unless economic technologies are developed for low temperature geothermal fields. Electricity production through renewable energy sources in Nepal stands at a mere 36.3 MWe, of which mini-hyro contributes 26.27 MWe, while solar, wind and bioenergy share 10.00 MWe, 0.018 MWe and 0.043 MWe respectively. Popularization of thermal spring areas will help only in the utilization of low temperature geothermal fluids for balneotherapy and recreation. The key to success lies in executing pilot/demonstration projects alone for its direct utilization. Geothermal heat pump installation and exhibiting prototypes in the mobile alternate energy village can be starting points. Pilot projects demonstrating its use for fish farming, greenhouse heating, agricultural drying, snow melting etc. alone can attract local entrepreneurs to invest money and propagate the importance of geothermal energy.

Table 3. Summary table of geothermal direct heat uses (as of December 2014)

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr = 10^{12} J/yr)	Capacity Factor
Individual Space Heating Direct Heating Air Conditioning (cooling) Greenhouse Heating Fish Farming Animal Farming Agricultural Drying Industrial Process Heat Snow Melting Bathing and Swimming Other Uses	3.316	81.112	0.88
Subtotal			
Geothermal Heat Pumps			
TOTAL	3.316	81.112	0.88

Table 4: Present and planned production of electricity

	Hydro		**Other Renewables**		**Total**	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014	746	0.560	36.331	0.027	782.331	0.587
Under construction in December 2014	1252	0.939	N/A	N/A	1252	0.939
Funds committed, but not yet under construction in December 2014	N/A	N/A	N/A	N/A	N/A	N/A
Total projected use by 2020	N/A	N/A	N/A	N/A	N/A	N/A

Sources: Economic Survey (2014) and Interim Plan (2013-2016), Nepal. N/A = Not Available. Production of electricity from other sources e.g. geothermal, fossil fuel and nuclear is non-existent.

The possibility to utilize wind energy which was considered infeasible by RECAST in early 80s has resurfaced in Nepal recently with the introduction of new hybrid technology. Likewise, after the termination of geothermal development efforts in 70s, the Department of Mines and Geology should rethink about it in the present context. The Alternate Energy Promotion Centre is active in some alternate sources of energy but it seems still passive in this energy sector for the lack of knowledge about its direct use. Likewise, RECAST is another institution which can take a lead role in undertaking both scientific studies and demonstration works for direct use. Without external technical support, these organizations do not seem to be in a position to conduct any pilot projects at the moment. The overall achievement of geothermal utilization in Nepal compared to other countries with high temperature fields is negligent. Advocacy for utilizing low temperature water for direct heat has been going for more than a decade in the international field. Evidently, such efforts have been less effective in a number of countries. Initiatives from bodies like International Geothermal Association to motivate related sponsoring agencies like World Bank, UNESCO, Asian Development Bank to conduct pilot scale direct use projects in countries like Nepal can be highly rewarding.

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