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Geothermal Updates for Pakistan

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PREAMBLE:

My Greetings, to every Geothermalist arriving from world, in a country at Earth's roof top, (Iceland). This country is prominent in geothermal resources having distinguished features of the nature. I congratulate Icelandic people for successfully exploiting their country's geothermal resources and demonstrating its practical benefits to other nations, particularly to those who have geothermal resources but not taking the benefit of it. Sadly, my country is perhaps among top of those nations.

Almost all my papers written for IGA claim that Pakistan is having geothermal resources. This firm belief and claim is based on a simple geological fact that country is sitting over the major portion of a junction of two gigantic continental plates, i.e. Austro-Indo (Australian-Indian) Plate from East and Eurasian Plate from West, North and North West. Wherever on earth such subduction boundaries of tectonic plates are found, geothermal energy is definitely available there and can be tapped because most of the earth energy is released through the crevices of these subduction boundaries. On the lithosphere, these subduction zone boundaries are also called transform-faults, while on ocean floors, they are called fracture-zones. Subduction or joining of these huge continental plates covers both lithosphere as well as asthenosphere portion of continental masses.

If the volcanoes are not found nearby, even then earth energy will be released either in the shape of earthquakes or in the shape of hot gases and hot springs.

There are few countries situated over the converged continental boundaries whereupon the collision between two continental tectonic plates took place and Pakistan is among those few countries of the world.

ENERGY POLICIES

Expanded Energy Scenario of Pakistan:

It was reported by me in my last papers (2010 and 2015) that Pakistan was suffering badly from electrical outages but after that, thanks to our governmental efforts, and a very valuable help came from China [Pakistan's only sincere friend and neighbor for 70 years]. Therefore, the energy scenario has now totally changed. Pakistan has come out of the crisis of power shortages. A new approach of "Energy Mix" was adopted that was based on exploiting all conventional and non-conventional energy resources. So, Oil, Coal, LNG, Hydro, Solar, Wind, Bagasse, all were brought into the scene and an increasing power generation output emerged in the following order:

1. In 2010 oil fuel based generation was around 14,000 MW, it was decided to add numbers of furnace oil based power plants (normally run on imported oil). Plan was to add 12,334 MW by 2018 with private sector as well as with Chinese help.

2. 20 private power producers were already generating electricity; however, the government became lenient for more power licenses.

3. Around 11 coal power plant projects came into existence with a total capacity of 7640 MW.

4. Then the private sector came ahead enthusiastically in the field of solar generation. So far the biggest solar project is Quaid-e-Azam Solar Power, that has 400 MW capacity. However, there are plans to increase the capacity up to 600 MW by 2020.

5. In private sectors wind power capacity was also explored, and 21 private wind power projects came into existence. Many wind power projects have already become operational with a combined capacity of more than 1500 MW

6. Sugar Mills of Pakistan have already become a big contributor of power, as they have the raw material "bagasse" available after sugar-cane crushing season. This waste-product coming out of sugar cane becomes an excellent fuel to burn in boilers and acquires heated steam for producing electricity. Known as bagasse-power, Sugar Mills in Pakistan are generating around 3600MW of electricity combined in 43 sugar mills.

7. Some cement plants have also begun to produce power through waste-heat recovery systems as well. Although the capacity is small i.e. 70 MW, the source is Green. The heat that would have otherwise gone up to increase the atmospheric heat is now being utilized.

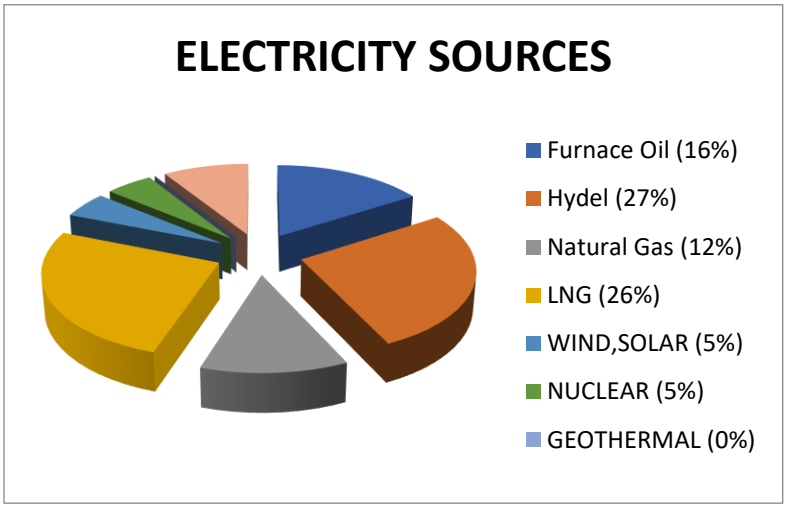

Figure 1: Electricity sources in Pakistan

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Solar, Wind, Bagasse)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
				(*)		(*)		(*)		(*)		
In operation in December 2019	0	0	28,399	78,818	7,116	32079*	1,142	6,278	1,465	2,950	38,122	120,125
Under construction in December 2019	0	0	500	2,400	5,600	26,880	0	0	353	1,742	6,453	31,022
Funds committed, but not yet under construction in December 2019	0	0	265	127	200	960	0	0	203	974	668	2,061
Estimated total projected use by 2020	0	0	29,164	81,345	12,916	27,840	1,142	6,278	2,021	5,666	45,243	153,208

Table Formats: By Geo-Heat Centre, USA

Prepared by SHS Bukhari (*) With off-load periods

In the above tables, once again I feel very sad to illustrate that usage of geothermal energy for power production is absolutely none and the source is totally neglected in Pakistan.

1. According to the statistics of NEPRA, by the year 2017 renewable energy power plants connected with PEPCO were providing only 1465 MW electricity.

2. By December 2018, Pakistan had finally achieved a total installed power generation capacity of over 34 GW. Even a de-rated capacity estimate was around 31 GW and all this became possible with a new approach of the government in mobilizing government and private sector simultaneously, and an important timely factor of Chinese financial assistance coming under China Pakistan Economic Corridor (CPEC) projects, with investment of $25 billion, and with a target of 12,334 MW capacity to be completed by 2020 on a priority basis.

Pakistan has only two big hydroelectric dams built until 1964. After that only minor capacity dams were built. However, the present government has begun work on comparatively bigger capacity hydro-dams on a priority basis.

World Bank data collected up to 2014 through the Government. of Pakistan figures shows that electrification rate of 97 percent has been achieved but the factual position remained different. In fact, millions of remote area homes and villages are still without electricity being out of the neglected distribution system. This developmental work needs huge investment and peaceful environment that is only possible with the stoppage of proxy-war being fought from the neighboring countries into Pakistani territory to bleed the nation economically.

EXHIBIT	AREAS COVERED	GEOLOGICAL SETTING
01	**Northern Pakistan Zone** Frontier Pronvince (Pakhtoonkhaw), Gilgit, Chitral, Kohistan Regions & Kashmir Regions.	Rocks of various ages including Lithological layers blocks, consisted of: • Igneous • Granite- Metamorphic • Granodiorite • Quartz • Phyllite • Chlorite • Conglomerate • Dolomite • Schist • Sandstone • Plutonic • Pelite • Pegmatite • Aplite
02	**Baluchistan Zone** Entire Baluchistan Province	Rocks of pyroclastic volcanism consisted from various ages of : Permean , Oligocene, Pleistocene, Triassic, Eocene, Miocene late to early ages: • Igneous • Granitic • Porphyritic • Phyllite • Granodiorite • Chlorite • Schist • Pyrite • Quartz • Metamorphic • Sedimentary
03	**Indus Basin & Western Sind** Indus Basin Region from Karachi extended up to Dadu is a part of Southern Kirthar Range	Predominantly Sedimentary formation along with Granitic Boulders & huge Blocks
04	**East, West North & South Punjab** South Western Punjab's Sedimentary formation on west of Indus River & Elevated Northern Region known as Pothowar + Salt Range	Rocks from Pre-Cambrian & Early to Late Permian ages mostly of: • Gypsum • Dolomite • Sedimentary • Metamorphic • Granitic Boulders

Figure 2: Geological settings of Pakistan

Pakistan is a country blessed by nature and is comprised of more than dozen ranges of mountain within the country including more than 14 of the highest world peaks. The highest are K2 (8611 meters) and Nanga Parbat (8126 meters), the rest are also above 7000 meters.

Other than the ***Karakorum***, ***Himalaya*** and ***Hindu Kush***, there are additionally many peaks in Pakistan that are above 7000 meters and are famous among climbers. These mountains ranges have East-West layout.

Name of Main Mountaineous Range	**Geological characteristics**
1. Korakorum Mountain Range.	PEGMATITES / MAFIC PEGMATITES
	BATHOLITHS
2. Hindu Kush Range	MYLONITIC
	SHEAR ZONIC
3. Himalaya Range	GRANITIC
	METAMORPHIC
	MAGMATIC
	IGNEOUS

Around seven of following mountain ranges with amazing and scenic beauty of landscapes are mentioned below. Most of these mountains Ranges have North-South layout:

4. Zom Range (include peaks of:

   Koyo Zom; Buni Zom;
   Ghamubar Zom; Gule Lasht Zom)
5. Safed Koh Mountain Range along
   Afghan border
6. Margla Hills Range
7. Salt Range
8. Koh-e-Suleiman Range
9. Kirthar Range
10. Toba Kar Range (Baluchistan)

SEDIMENTARY,

METAMORPHIC,
METAVOLCANIC

IGNEOUS

METASEDIMENTARY
BASALTIC

Besides the above dense rock ranges, there are also small concentrations of hilly ranges along the coastal belt of Pakistan from Gawadar in West to Run of Kutch in the East.

OTHER POTENTIAL GEOLOGICAL ZONES OF PAKISTAN, SUITABLE FOR GEOTHERMAL EXPLORATION

Sub-tectonic Fault Lines areas are considered potential zones for geothermal exploration. This time I am giving hereunder the chart of some known fault lines in Pakistan Chaman Fault about 1000 km and is the longest fault of this sub-continent. Although this subject itself needs a lengthy discussion and information:

LIST OF FAULT LINES IN PAKISTAN

Pakistan has all sorts of Faults & Lines Lines in its geology

1	Allah Bund Fault (Runn of Kutch, Sindh)
2	Bannu Fault (Bannu, KPK)
3	Chaman Fault (Chaman, Baluchistan)
5	Hoshab Fault (Turbat, Baluchistan)
6	Jhelum Fault (Punjab)
8	Kalabagh Fault (Punjab)
9	Kirthar Fault (Sindh)
10	Kirthar Fault (Sindh)
11	Karakorum Fault
12	Central Karakorum Fault
13	Kurram Fault (KPK)
14	Kurram Fault (KP)
15	Kutch Mainland Fault
16	Main Boundary Thrust
17	Main Karakoram Thrust
18	Main Mantle Thrust
19	Makran Coastal Fault
20	Muzzafarabad Faul
21	Nagar Parkar Fault (Sindh)
22	Nai Rud Fault
23	Ornach-Nal Transform Fault
24	Pab Fault (SN)
25	Punjal-Khairabad Thrust (PJ)
26	Quetta-Chiltan Fault
27	Raikot Fault (Sindh)
28	Riasi Thrust
29	Salt Range Thrust (Punjab)
30	Tirchmir Fault
31	Tanda Fault (AJK)
32	Himalayan Frontal Thrust

VOLCANIC AREAS OF PAKISTAN

After looking at the coastal belt energy resources, let us have a look over volcanoes of Pakistan. Volcanic regions are considered highly favorable spots to explore the geothermal energy. Pakistan's volcanic regions are entirely located in Pakistan's biggest province of Baluchistan. Besides Hingol National Park, the western border with Sistan Iran is also connected with volcanic activities. Extinct mud volcanoes exist through a very wide area in Baluchistan and Seistan (Iran). These are mud volcanoes in Hingol and earth energy spews out of them. The following regions have been marked as volcanic regions:

For details of mud volcanoes of Baluchistan, please refer to my paper of 2015 available in IGA's papers data-base.

Figure 3: Mud volcanoes

GEOTHERMAL SPRINGS OF PAKISTAN

#	Name of Resource	Location on geological map	Resource Character-istic	Geological Background
01	Murtazabad Springs	Hunza Region, Northern	Shallow	Area of MMT (Main Korakorum Thrust) from Pre-Cambrian ages, and consisted of Cenozoic and Mesozoic in nature.
02	Budelas Valey Springs	Hunza Region, Northern Pakistan	Shallow	
07	Gram Chashma	Chitral	Deep	Karakorum Block with rocks of Ordovician ages
03	Dasu Springs,	Kohistan Region	Shallow	A unique arc among the surrounding geological formation, the area is known as Kohistan Island Arc and is from cretaceous in age and holds the Rocks from early Paleozoic periods
04	Mushkin Spring,	Northern Pakistan	Shallow	
05	Tatta Pani,	Astor River area, Northern Pakistan	Deep	
06	Sassi.	Sakardu Region, Northern Pakistan	Deep	
07	Tatta Pani,	Azad Kashmir	Deep	
08	Karsaz Spring	Karachi, Sind	Shallow	Receding chain of Baluchistan elevations is Kirthar Range divided into Northern & Southern Kirthar Ranges. Southern Kirthar is extended into Sind up to Karachi.
09	Manghopir Spring	Karachi, Sind	Shallow	
10	Kharan & Kohe-Sultan Springs	Kharan & Chaghi Regions, Baluchistan	Shallow	from Quaternary age
11	Medium & Low Thermal Gradient Springs of: • Sehwan • Talhar • Khaskheli • Garm Ab	Indus Basin & Western Sind	Shallow	Late Jurassic to Late Cretaceous Era rocks
12	Medium & Low Thermal Gradient Springs of: • Taunsa • Bhakkar • Uch	Northern Punjab Pothowar Region & South Western Punjab	Shallow	Pre-Cambrian times from Proterozoic to early Paleozoic ages rocks

Hot Spring to Manghopir also being used to raise crocodiles.

Hot Spring of Drig Road, Karachi.

Besides exploiting the sources mentioned above, I would like to remind about an extraordinary dry-steam source of geothermal energy available to Pakistan in Nanga Parbat. This source is parallel to the dry-steam source of Tuscani, Italy.

Figure 6: A photo of Nanga Parbat by Moiz Ismail published by www.outdoorjournal.com on March 03, 2019

CONCLUDING REMARKS:

I had written a small book in year 2000-2001 to draw attention towards this wonderful source of energy of my country. At that time only around 3-4 countries were developing geothermal energy. Now almost 60 countries of world are busy in developing and utilizing this wonderful source of nature. In 2002, WAPDA's Chairman showed its interest in this new source of energy and called upon me for a meeting. In my meeting I also arranged a direct interaction between WAPDA and IGA. But while these developments were taking place, a restructuring arrangement of WAPDA came into force and WAPDA powers were limited to dams constructions only. Since 2002, a continuous campaign through articles on geothermal energy continued from me. My voice became most effective through articles written via the IGA platform, but here in my own country, no government organization or private institution ever appreciated me. Now age-wise and health-wise I am on the last stages and it is again IGA that has realized my efforts and honored me with a title this year (2019) as Geothermal Ambassador for Pakistan. I still believe that only a government organization can truly take the task to make Pakistan as a Geothermal Country.

REFERENCES CITED:

List of Fault Lines https://en.wikipedia.org/w/index.php?title=List_of_faults_in_Pakistanandaction=editandsection=4

Photo of Nanga Parbat by Moiz Ismail published by www.outdoorjournal.com on March 03, 2019