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Research study on geothermal energy and earthquakes in India

Pratyush and Dr. JP Yadav

Abstract
The most efficient domestic option for sustainable and renewable energy, as well as a replacement for additional sources of energy, particularly those made from coal and petroleum, is geothermal energy. Due to the small amount of greenhouse gases, it releases, this source of energy is environmentally friendly. Even though it isn't employed entirely because of issues like location and high costs, it will end up being the least expensive method of power generation in the future when these conventional fuels start to run out. Although the initial outlay is very high, the long-term savings and efficiency far outweigh that. It has cheap operating costs because it uses no fuel to generate electricity, saving 80% in comparison to fossil fuels. A theory that can effectively describe all earthquake occurrences worldwide as well as general geodynamics is put forth in this study. In essence, geothermal energy is what causes the plates to pause, strike, and tip over. Geothermal energy constitutes the main power; the plates are only working solids. The earth is shaken along the boundaries of plates by the ferocious flow and tremendous pressure of this power, which also causes intra-plate seismicity. It is suggested that by utilizing the excess geothermal energy, the severity and risk of approaching earthquakes can be significantly decreased in light of the findings from the currently operating geothermal power plant located near the Big Geysers in California, which have been documented by the California Energy Commission. The relationship between geothermal energy and earthquakes encourages people to believe that the earth's crust would be less trembling if we could somehow release this extra energy (0.01%).

Keywords: Seismicity, world geothermal energy, earthquake, power generation

Introduction

Earth is an extremely active planet, in contrast to other planets in the solar system. Its inside is constantly bustling with activities. Since the earth's creation, hundreds of millions of years ago, there has been constant geological change. Because of this, the continents on the surface were quite distinct from how we know them today in terms of their shapes and locations [1]. The earth's internal heat source pushes against the surface, causing geodynamic and geothermal phenomena such as stunning volcanoes, high heat flow zones, etc. The deformation of continental plates across the lines of faults is the basic basis for the present understanding of earthquakes. The plate-tectonics theory refers to it. Under the crust and lithosphere, hard plates are regularly and slowly rotating. Even though it has been shown that the majority of earthquakes happen along these faults that are connected to plate boundaries, this hypothesis does not fully account for other phenomena, such as mid-plate seismicity, tranquil (seamless) fault lines, deep hypocenters, etc. Following the analysis, a cause-of-earthquake theory is put forth that can satisfactorily account for the entire earthquake dynamics. In accordance with this, the primary cause of geo-dynamism, the movement of plates, and subsequently earthquakes along fault lines and in the earth's thermally permeable and brittle zone is excessive geothermal power pressure. The argument is made that by using the excess pressure of geothermal energy as electricity and other forms of energy, the movement of plates and other types of earthquakes may be prevented. The potential earthquake's intensity can be significantly decreased as a consequence.

According to known scientific data, both the crust and the upper mantle of the planet are predominantly made up of solid rocks. According to geologists, the solid minerals of the crust and the mantle must be heated to temperatures between 750 and 10,000 degrees Celsius in order for them to melt and produce magma [2]. The temperature and pressure might each reach up to 6,000 °C and 360 GPa, respectively, near the planet's center [3].

Geothermal energy refers to the heat that the earth's interior stores and then spews out as stunning volcanoes, hot rocks, hot springs, etc.

Since it produces a very small quantity of environmental contaminants compared to other forms of energy, this energy is hailed as clean and green. This is a home energy source that is more affordable, reliable, and environmentally friendly than other energy sources. It helps maintain the energy source by producing power for electricity and providing direct heat.

There are several geothermal sources located across the world, and many nations use this energy for both residential and commercial purposes. India has seven primary geothermal regions that have been found, but nothing has been done to effectively harness the energy for the purpose of generating power. Himachal Pradesh is located in the western region of the Himalaya, which is the world's biggest geothermal region. One of the biggest problems facing the state of Himachal is the earthquake tragedy. Research has indicated that using the energy from Himachal Pradesh's several geothermal locations, including Manika ran, Tattapani, Manali, and others, can help meet the state's expanding energy demands while also reducing the state's vulnerability to seismic disaster.

According to the WGC2015 report, global energy production increased by about 1.7 GW between 2010 and 2015, or roughly 16%, following a roughly 350 MW/year standard upward trajectory and a noticeable increase from the prior period's average value of about 200 MW/year (Bertani, 2005a, 2005b, 2006, 2007, 2010, 2012, and 2013). Geothermal energy is one alternative with a lot of promise but is frequently overlooked, according to a worldwide review of renewable energy resources, as shown in the WGC2015 report's country-by-country update. Figure 1 and Table 1, together with Figures 2 and 3, provide the total capacity that is installed by geothermal power plants globally. In table 2, information from all the nations that currently produce electricity using geothermal energy is shown, along with the total capacity installed and annual energy production values from 2010 and 2015, as well as the growth since 2010 in both absolute numbers and percentages. The capacity that has been installed is also predicted for the short term, up to the year 2020. A globe map showing the installed capacity for the year 2015 is shown in Figure 4 [4].

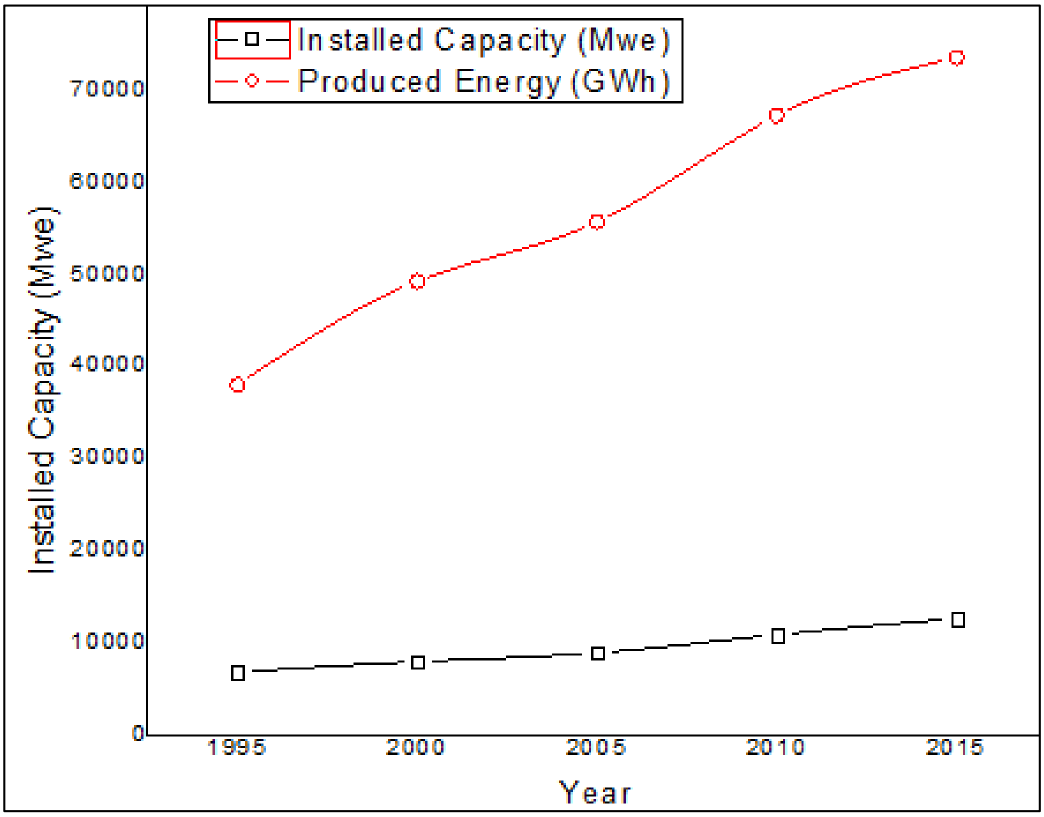

Fig 1: Overall capacity that has been installed globally

Table 1: Worldwide capacity actually installed totals from 1995 to the end of 2015, as well as continent-specific short-term forecasts

Europe	Installed in 1995	Energy in 1995	Installed in 2000	Energy in 2000	Installed in 2005	Energy in 2005	Installed in 2010	Energy in 2010	Installed in 2015	Energy in 2015	Forecasting for 2020
Country	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
Europe	722	3.881	1.019	5.864	1.124	7.209	1.643	11.371	2.133	14.821	3.385
Africa	45	366	52	397	136	1.088	209	1.44	601	2.858	1.601
America	3.8	21.303	3.39	23.342	3.911	25.717	4.565	26.803	5.089	26.353	8.305
Asia	1.98	10.129	3.075	17.39	3.29	18.903	3.661	23.127	3.756	22.084	6.712
Oceania	286	2.353	437	2.269	441	2.792	818	4.506	1.056	7.433	1.44
Total	6.832	38.032	7.973	49.261	8.903	55.709	10.897	67.246	12.635	73.549	21.443

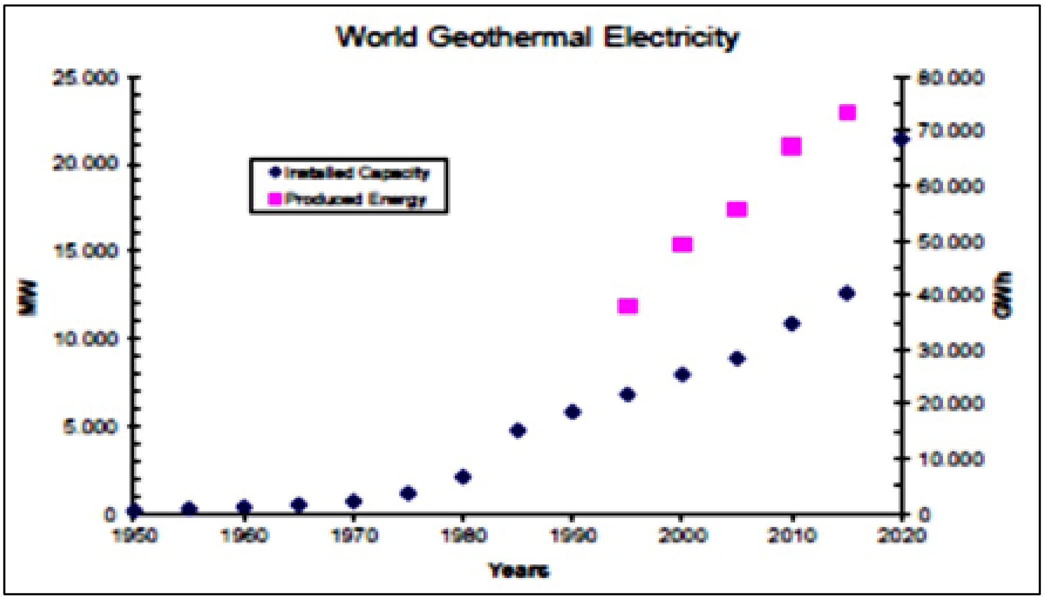

Fig 2: Electricity generated between 1950 and 2015 (right, GWh) and the capacity actually installed (left, MWe)

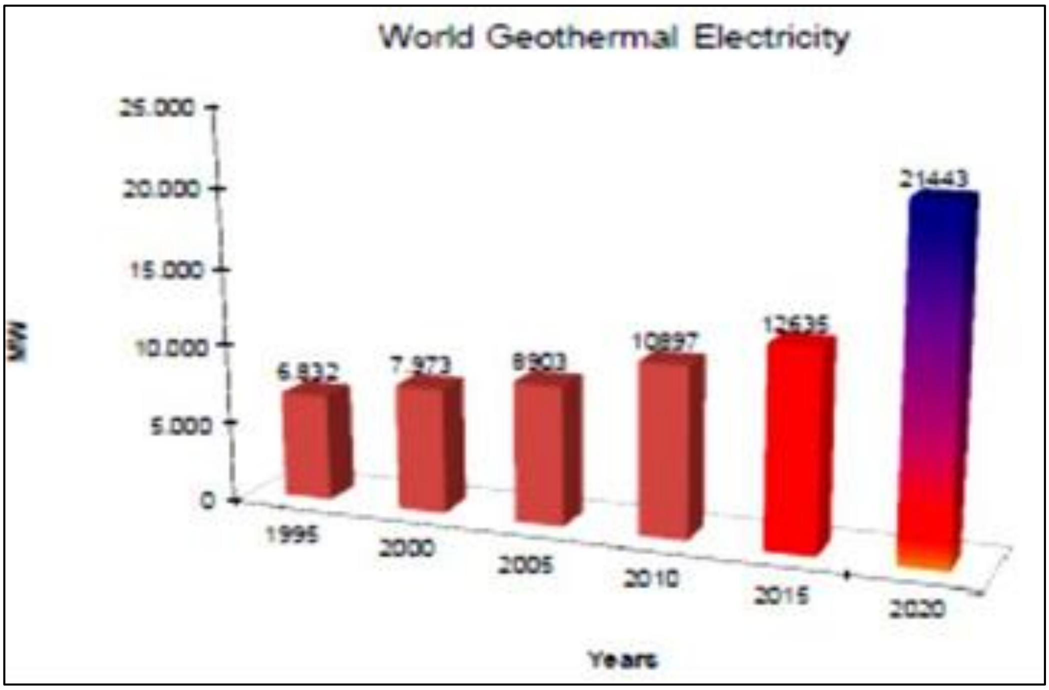

Fig 3: Prediction of the current installed capacity [21.4 GWe] in 2020

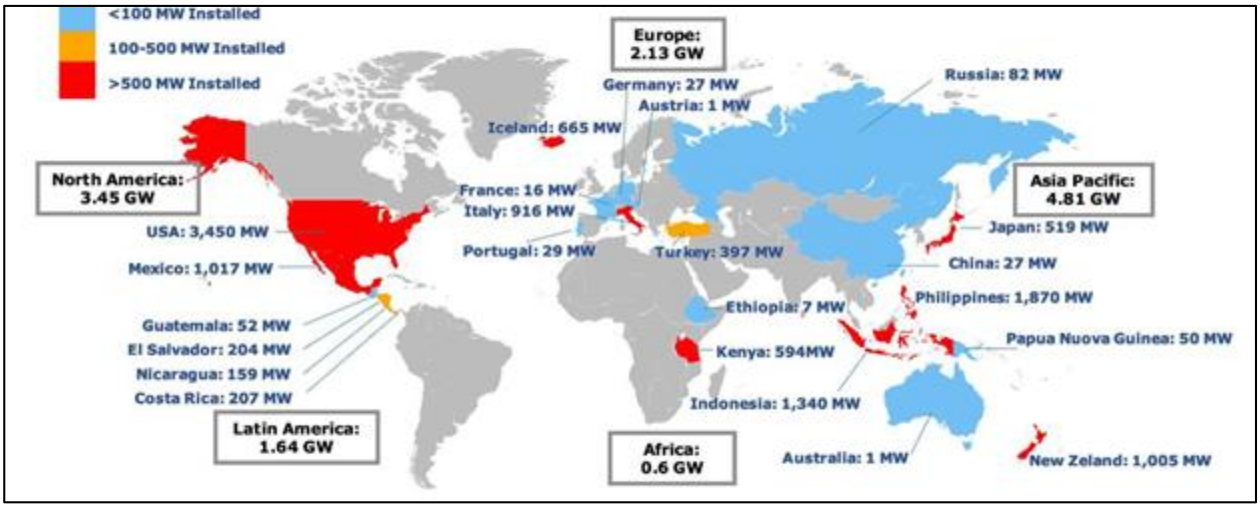

Fig 4: Global installed power capacity in 2015 reached 12.6 GWe

Table 2: Forecasts for the total capacity installed and energy production for the years 2010, 2015, and 2020

Country	Installed in 2010	Energy in 2010	Installed in 2015	Energy in 2015	Forecast for 2020	Increase since 2010			
								Capacity	Energy
	MWe	GWh	MWe	GWh	MWe	MWe	GWh	%	%
Algeria					1				
Argentina					30				
Armenia					25				
Australia	0.1	0.5	1,1	0,5	20	1			
Austria	1.4	3.8	1.2	2.2	6				
Bolivia					40				
Canada					20				
Chile					150				
China	24	150	27	150	100	3		12%	
Costa Rica	166	1,131	207	1,511	260	42	380	25%	34%
Czech Republic					5				
Djibuti					50				
Dominica					10				
Ecuador					40				
El Salvador	204	1,422	204	1,442	300		20		
Ethiopia	7.3	10	7.3	10	50				
France	16	95	16	115	40		20		21%
Germany	6.6	50	27	35	60	20	-15	280%	-30%
Greece					40				
Guatemala	52	289	52	237	140				
Honduras					35				
Hungary					5				
Iceland	575	4,597	665	5,245	1,300	90	648	16%	14%
India					10				
Indonesia	1,197	9,600	1,340	9,600	3,500	143		12%	
Iran					5				
Italy	843	5,520	916	5,660	1,000	74	140	9%	3%
Japan	536	3,064	519	2,687	570	-16	-377	-3%	-12%
Kenya	202	1,430	594	2,848	1,500	392	1,418	194%	99%
Latvia					5				
Mexico	958	7,047	1,017	6,071	1,400	59	-976	6%	-14%
Montserrat					5				
Netherland					5				
Nevis					35				
New Zealand	762	4,055	1,005	7,000	1,350	243	2,945	32%	73%
Nicaragua	88	310	159	492	200	72	182	82%	59%
Papua-New Guinea	56	450	50	432	70	-6	-18	-11%	-4%
Peru					40				
Philippines	1,904	10,311	1,870	9,646	2,500	-34	-665	-2%	-6%
Poland					1				
Portugal	29	175	29	196	60		21		12%
Romania			0,1	0,4	5	0,1	0,4		
Russia	82	441	82	441	190				
Slovakia					5				
Spain					40				
Switzerland					3				
Taiwan			0,1		1	0,1			
Thailand	0.3	2	0,3	1,2	1				
Turkey	91	490	397	3,127	600	306	2,637	336%	539%
UK					15				
USA	3,098	16,603	3,450	16,600	5,600	352		11%	
Total	10,897	67,246	12,635	73,549	21,443				

Note: Yellow shading over red is the geothermal power generating country in Asia

Statistical Highlights [4]: Figures 5 and 6, respectively, indicate the top 5 nations for capacity & generated energy and absolute value rise

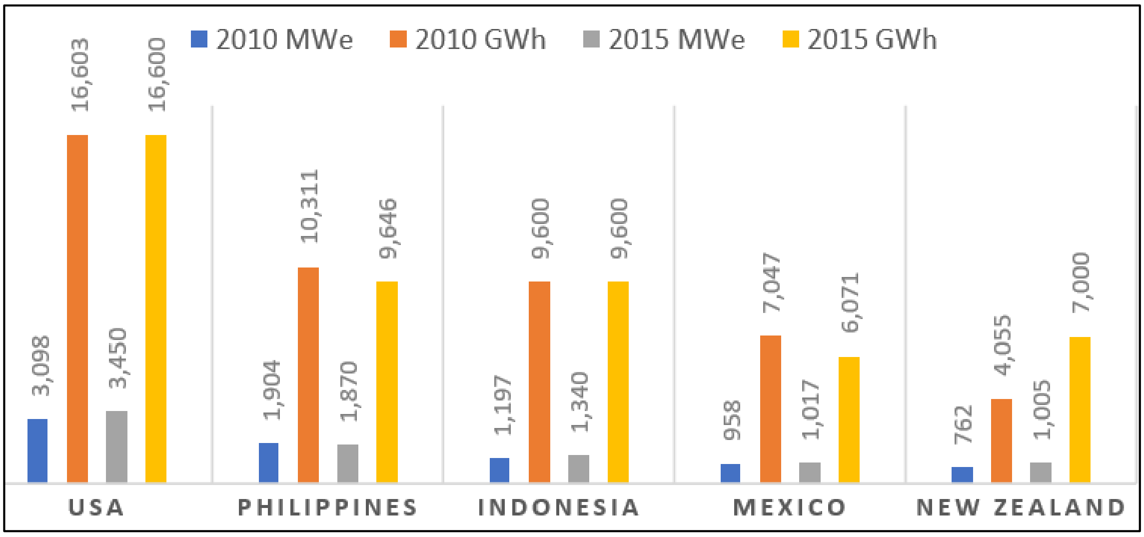

Fig 5: Leading five nations for capacity establishment between 2010 and 2015

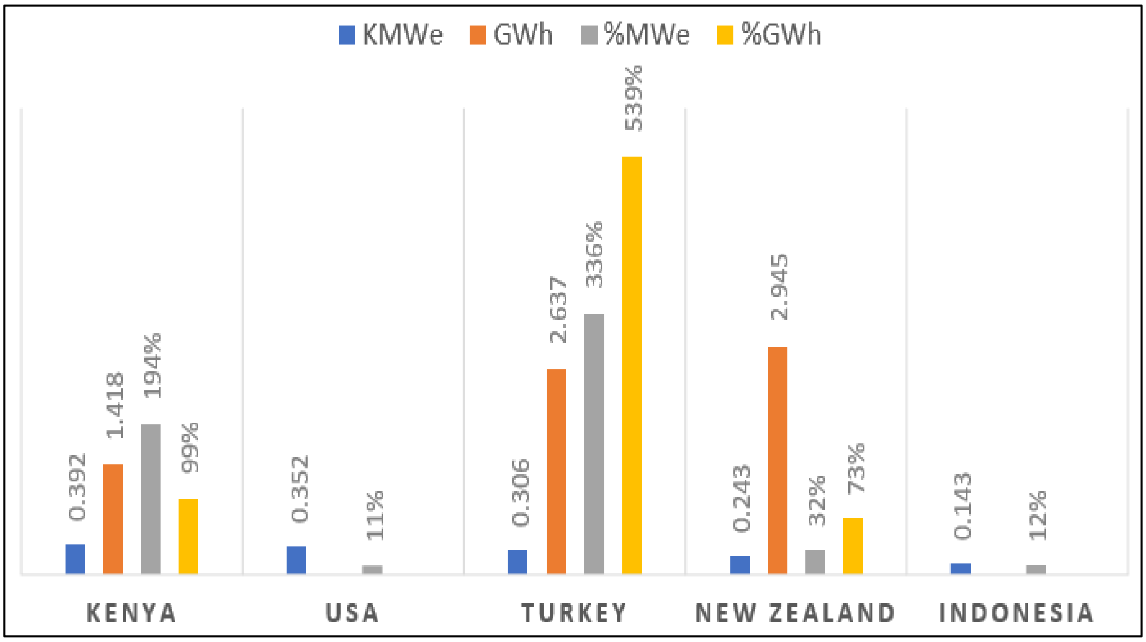

Fig 6: Top five nations for absolute MWe growth since WGC2010

Earthquake and Current Perception

By 1968, a more comprehensive theory of "plate tectonics" that combined the notion of continental displacement with another notion of "seafloor spreading" arose [1]. According to the hypothesis, the earth's outer, hard lithosphere is made up of around six large, separate portions, or "plates," that are arranged spherically. The Euro-Asiatic, Indo-Australian African, American, Antarctic and Pacific plates are located between these larger plates. The resultant lines across where the plates joined unevenly are referred to as "faults". The friction on the edges of the plates as they move together is what causes earthquakes. This is thought to be the primary cause of the majority of earthquakes that have occurred along these faults connected to plate borders. Rapid energy release causes the ground to vibrate during an earthquake. Beginning from the point of origin, the energy is emitted as spherical fronts of wave energy in all directions [1]. The epicenter is the location on the surface that corresponds to the hypocenter, which is the source located deep below the ground. Seismology is the scientific investigation of seismic waves, which are the waves produced in this way from the source.

Most earthquakes happen at depths of up to a few tens of kilometers. The phrase "shallow- focus" refers to earthquakes that have a focal depth of less than 70 km, whereas "mid-focus" or "intermediate-depth" refers to earthquakes that have a focal depth of between 70 and 300 km. 'The deep-focus' earthquakes, however, have the potential to happen at significantly larger depths (between 300 and 700 km). The Wadati-Benioff regions are earthquake-prone seduction regions.

The Hypothesis

The planet was once a fireball that developed as a consequence of the collisions of millions of burning meteoroids that came from cosmic debris. The fireball has been burning within ever since it was created, and the outer layers have done a fantastic job of insulating the heat. The self- sustaining natural nuclear fission reactor replenishes a worldwide terrestrial heat flow of 44.2 Terawatts (TWts) of power at a rate of 30 TWts per second. The solid earth, including mountain building, the movement of plates, earthquakes, and volcanism, is energized by the energy that is widely spread throughout the rest of the globe. All geodynamic processes, including the creation of the geomagnetic field, are driven by the heat present inside the planet. The planet continuously releases heat into the earth's atmosphere at a rate of 0.3 x 107 M Wt (1.1 x 1014 Btu/hr), and the average worldwide heat flow is 87 milli Wts/m2. It should be noticed that the plate borders are where the high heat flow values are found. In addition to the plate borders, regions under strain with a thinned crust also exhibit significant heat flow values. Although the most significant heat flow values in the seas are located close to the area of ridges in the ocean floor, the high heat flow values on continents generally come from volcanic and seismically active areas. In the case of geothermal energy, we may claim that the effects of geothermal and its offshoot geodynamics coexist at plate borders on the surface of the globe. Geothermal resources with high temperatures (220 °C to 350 °C) are found along plate borders, while those with low to intermediate temperatures (50 °C to 220 °C) are distributed in the middle of plates, according to surface measurements and hotspot data. We contend that although low- to intermediate-temperature geothermal energy sources support intra-plate seismicity, high-temperature geothermal assets cause earthquakes near plate borders. The majority of the earth's geothermal energy escapes as heat and eventually radiates into space via volcanoes, hotspots, hot springs, etc. Nevertheless, a very small portion of this energy gets released during earthquakes, where the passage is quite difficult. A recent analysis suggests that the mud discharge may have really been a natural seismic response [5]. This justification supports the geothermal genesis of earthquakes as well. If there is any fragile component of the plate, it cracks under the excess pressure of geothermal energy in the interior, causing an earthquake and the beginning of mud flow. The eruption or mud flow may be located quite a distance from the epicenter. Most of the time, it merely breaks the plate, and no mud escapes since there isn't a clear path. Thus, an earthquake has occurred but no mud eruption has been noted.

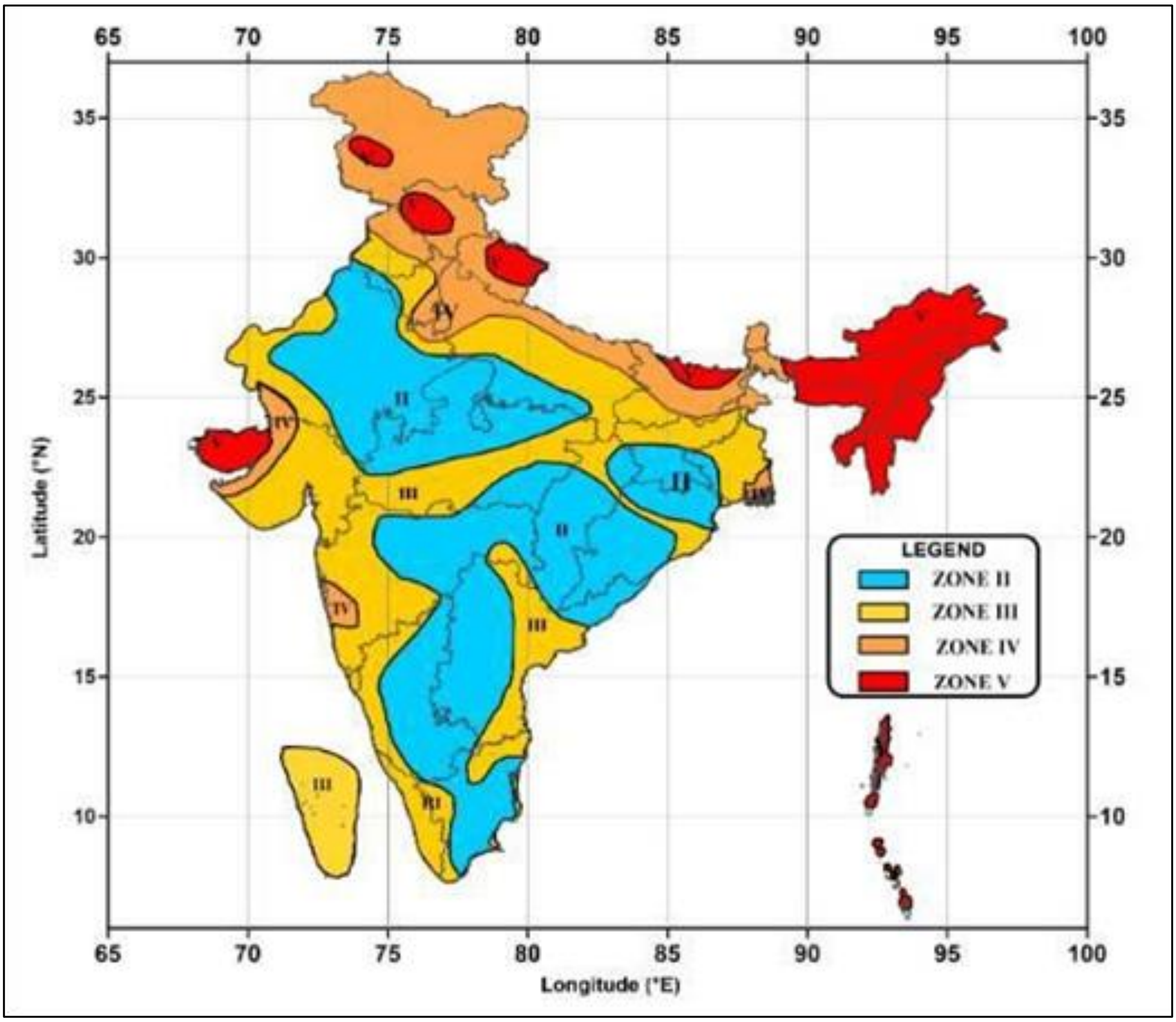

Fig 7: India's seismic zone map [6]

India's heat flow regions and earthquake zones

A large portion of the peninsula of India was designated as non-seismic by the seismic zoning of the nation, which was laid forth in the Code. The IS code has undergone several changes, and the most recent code (IS 1893–2002) has been broken down into five components, each of which is appropriate for a distinct kind of building. Since it is based on historical data that spans a few hundred years, the projected earthquake's magnitude or severity in these areas is not well known. It is well known that the earthquake risk in the country is higher in the Himalayan area. For instance, the 2005 earthquake in Kashmir was stronger than what was predicted by IS regulations for that area. Even less is known about the earthquake risk in areas outside of the Himalayas.

The Killari earthquake (1993) took place in an area designated as seismic Zone-I, which indicated a low likelihood of destructive earthquakes. Improving our knowledge of the seismic risk in the nation is urgently needed so that construction can be constructed to take the right amount of earthquake shaking into account. The map below displays India's seismic zone location.

There are actually four (II-V) zones in the area, each with different seismically prone locations. Zone II depicts the area with the lowest seismic likelihood, while Zone V represents the largest scale of earthquakes. One can easily confirm this by contrasting it to the heat flow map [7] shown in Figure 7 below, which shows that the highest heat flow region (Zone-I) correlates with the most earthquake-prone area (Zone-V), and the area with the lowest heat flow region (Zone-V), to a good extent, has connections with the smallest earthquake-prone area (Zone-II). It may be deduced that the heat transfer quantity of the linked geothermal region is exactly proportional to the quantity of excess energy from geothermal sources that built up and detonated in the form of earthquakes. The strongest earthquakes occur most often in the red zones (Zone-I) with heat flow values higher than 180 milli Wts/m2. The Himalayan geothermal region has the greatest heat flow value, 498 milli Wts/m2, and it accounts for over 60% of all the destructive earthquakes that have occurred in India.

The Heat Flow Map makes it evident which cities, including Hyderabad, Bangalore, and Lucknow, are located in the yellow Zone-V zones with heat flow values under 40 milli Wt/m2. These places are earthquake-proof since the heat flow values are so low that they cannot generate earthquakes. Despite being close to the Himalayan plate border and being part of the Gangetic Plain, the area around Kanpur, Allahabad, and Varanasi has never experienced an earthquake danger, according to records. It should be highlighted that, in contrast to the heat flow map (Figure 8), the seismic zone map (Figure 7) has a solid scientific basis and is instead more of a trial-and-error map.

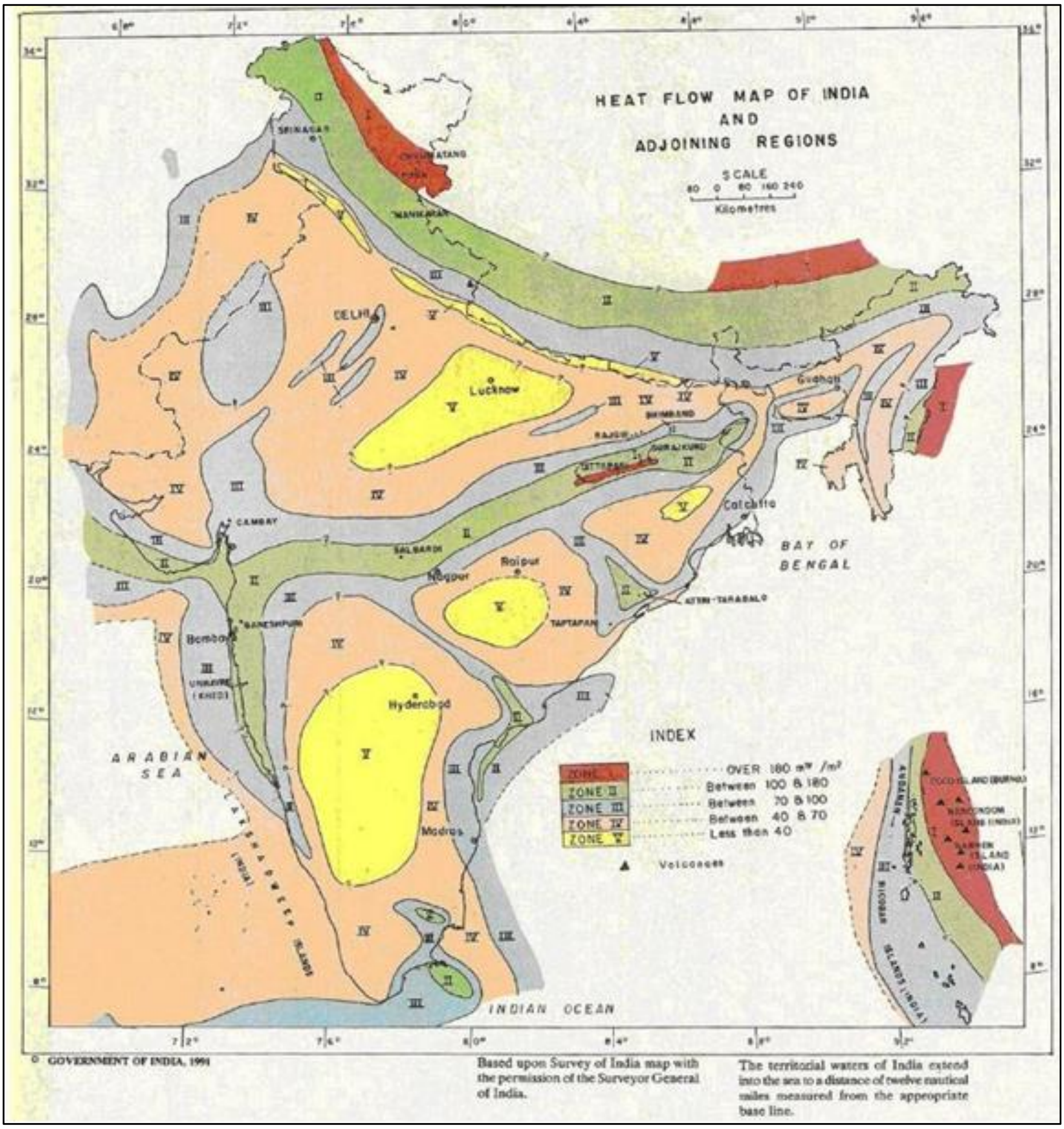

Fig 8: Indian heat flow diagram [7]

Indian Geothermal Provinces and Earthquakes

Around 45 million years ago, the Himalayas were created as a result of the collision of the Indian and Eurasian plates. The Himalayas are one of the world's largest geothermal belts, stretching over 3000 km through parts of India, Tibet, Yunnan (China), Myanmar, and Thailand and containing more than 1,000 hot spring areas. There are more than 150 of these places that are hot enough to produce power. On the eastern extremity of the Himalayan Geothermal Belt is an arc of volcanic islands that includes Coco Island in Burma, Nar-Condom Island in India, and Barren Island in India. The following table presents year-by-year information for the peninsula and the nearby geothermal provinces experiencing significant earthquakes with Richter scales (> 4) between 1819 and 2014.

Table 3: Earthquakes that are supported by India's geothermal regions

<table>
<tr><th>Year</th><th>Region</th><th>Magnitude</th><th>Toll</th><th>Name of Associated Geothermal Province</th></tr>
<tr><td>1819</td><td>Kutch, Gujarat</td><td>8.0</td><td>2,000</td><td>Cambay</td></tr>
<tr><td>1885</td><td>Sopore, JK</td><td>7.0</td><td>2,000</td><td rowspan="7">Himalaya</td></tr>
<tr><td>1897</td><td>Shilong</td><td>8.7</td><td>1,542</td></tr>
<tr><td>1905</td><td>Kangra, HP</td><td>8.0</td><td>19,500</td></tr>
<tr><td>1918</td><td>Assam</td><td>7.6</td><td>NA</td></tr>
<tr><td>1930</td><td>Assam</td><td>7.1</td><td>NA</td></tr>
<tr><td>1934</td><td>Bihar – Nepal</td><td>8.3</td><td>10,700</td></tr>
<tr><td>1941</td><td>Andaman Island</td><td>8.1</td><td>NA</td><td rowspan="3"></td></tr>
<tr><td>1943</td><td>Assam</td><td>7.2</td><td>NA</td></tr>
<tr><td>1950</td><td>Arunachal</td><td>8.5</td><td>1,526</td></tr>
<tr><td>1956</td><td>Gujarat</td><td>7.0</td><td>113</td><td>Cambay</td></tr>
<tr><td>1960</td><td>Delhi</td><td>6</td><td>Nil</td><td>Sohana</td></tr>
<tr><td>1967</td><td>Koyna, Maha</td><td>6.5</td><td>177</td><td>West Coast</td></tr>
<tr><td>1970</td><td>Bhadrachalam, AP</td><td>6.5</td><td>Not Known</td><td>Godavari</td></tr>
<tr><td>1970</td><td>Broach, Gujarat</td><td>5.7</td><td>Not Known</td><td>Cambay</td></tr>
<tr><td>1975</td><td>Himachal Pradesh</td><td>6.5</td><td>Not Known</td><td rowspan="3">Himalaya</td></tr>
<tr><td>1988</td><td>Bihar – Nepal</td><td>6.4</td><td>900</td></tr>
<tr><td>1991</td><td>Uttarkashi, UP</td><td>6.6</td><td>2,000</td></tr>
<tr><td>1993</td><td>Latur, Maha</td><td>6.3</td><td>9,748</td><td>West Coast</td></tr>
<tr><td>1997</td><td>Jabalpur, MP</td><td>6.0</td><td>38</td><td>SONATA</td></tr>
<tr><td>1999</td><td>Chamoli, UP</td><td>6.8</td><td>100</td><td>Himalaya</td></tr>
<tr><td>2001</td><td>Bhuj, Gujarat</td><td>8.7</td><td>19,988</td><td>Cambay</td></tr>
<tr><td>2004</td><td>Andaman Island</td><td>7.5</td><td>2,000</td><td rowspan="2">Himalaya</td></tr>
<tr><td>2005</td><td>Muzafarabad,JK</td><td>8.5</td><td>36,000</td></tr>
<tr><td>2007</td><td>Bahadurgarh, HR</td><td>4.3</td><td>Nil</td><td>Sohana</td></tr>
<tr><td>2009</td><td>Andeman Island</td><td>7.7</td><td>26</td><td rowspan="5">Himalaya</td></tr>
<tr><td>2011</td><td>Gangtok, SKm</td><td>6.9</td><td>118</td></tr>
<tr><td>2012</td><td>Andeman Island</td><td>6.2</td><td>0</td></tr>
<tr><td>2013</td><td>J &K</td><td>5.8</td><td>2</td></tr>
<tr><td>2014</td><td>Andeman Island</td><td>6.7</td><td>0</td></tr>
</table>

India's geothermal sites and generating capacities

Geothermal energy in India has enormous potential. There are a number of geothermal areas that exhibit high heat flow (78–468 mW/m2) and gradients of temperature (47–1000 C/km). India has a total operational capacity of 1313 MW, or less than 2% of the total potential, for generating electricity from renewable sources, out of a total estimated capacity of roughly 60,600 MW for non-conventional energy sources. As of right now, Table 1 shows that the operational capacity of the power plants is greatly outstripped by the amount of power produced from non-conventional resources.

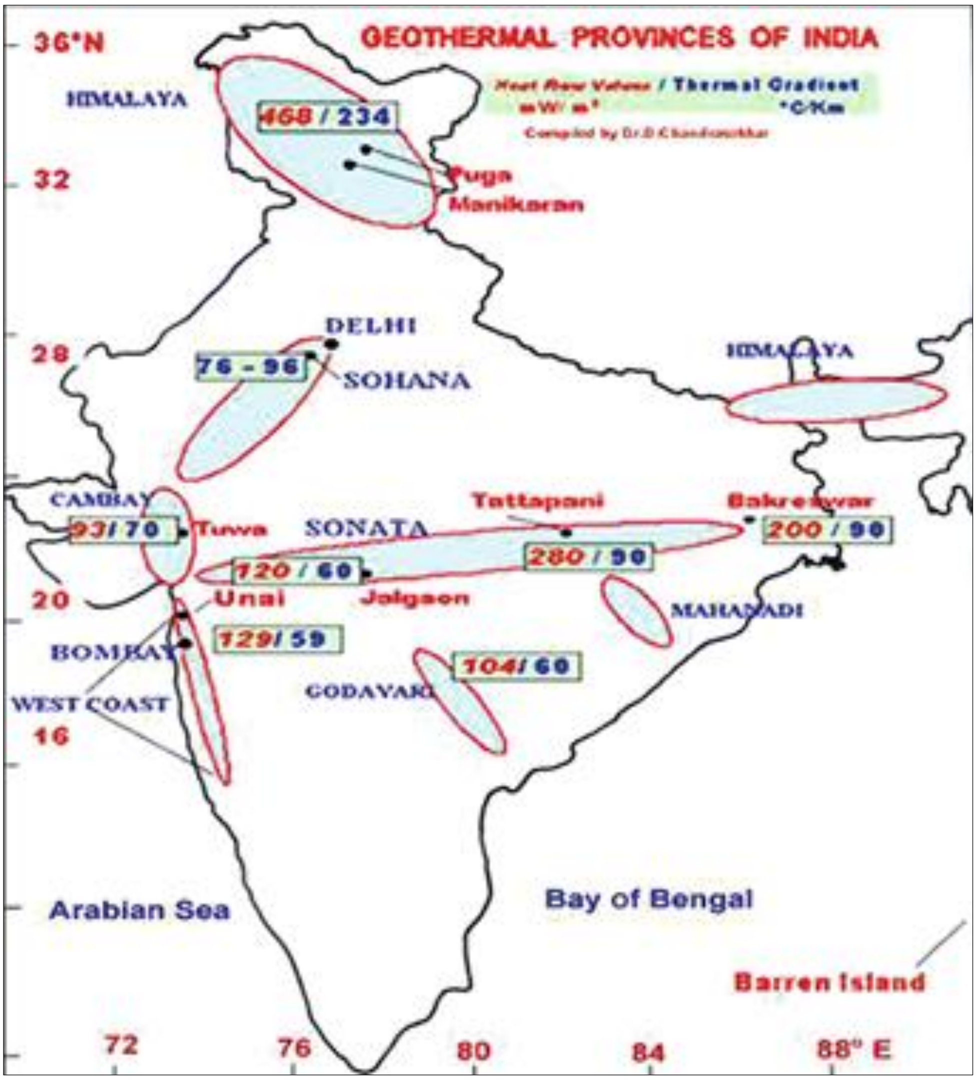

Fig 9: Indian regions with geothermal energy

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Table 4: State of non-conventional energy resources at the present [8]

Renewable Power	Potential	Achieved
Wind Power	20,000 MW	1,000 MW (5%)
Small Hydro Power	10,000 MW	172 MW (< 2%)
Biomass	20,000 MW	141 MW (0.7%)
Solar photo-voltic Power	20 MW/sq.km	810 KW/sq.km (4%)
Geothermal Power	10600 MW	--

There have been thorough geological, geophysical, and tectonic studies conducted by several study organisations. These studies have located a number of geothermal locations that can produce both direct usage and electricity. When the water temperature is less than 150 °C, direct-use technologies are typically used. At the moment, not many efforts have been made to use heat to create electricity.

The most potential geothermal resource is allegedly the Tattapani geothermal area in Chhattisgarh. The National Thermal Power Corporation (NTPC) has been given permission by the state government to build a power plant in the Tattapani region of the Balarampur district. Other prospective locations include Puga and Chhumathang in J&K, Cambay Graben in Gujarat, Suraj Kund in Jharkhand, and Manika ran in Himachal Pradesh. Thus, all of the aforementioned thermal provinces may be utilized for both direct usage and power generation using the technologies at hand. 10,600 MW of power may be produced by these provinces [9]. The future of the geothermal energy industry in India seems promising given the country's rising energy demands, current open economic policies of the government, and significant incentives provided to non-conventional energy sectors.

In reality, in the 1980s, the Geographical Survey of India and National Aeronautical Laboratories erected a 5-kW experimental binary cycle power plant in Manika ran in Himachal Pradesh (which is situated in the Parbati valley, southwest of Puga), using R113 as a secondary fluid. Sadly, landslides forced the closure of this factory [10]. The Geological Survey of India also carried out effective space heating tests in the province utilizing thermal discharge.

Energy production and its impact on earthquake magnitude

Americans, Filipinos, Italians, Argentines, Australians, Ethiopians, French, Greeks, Portugueses, Russians, Thais, Mexicans, and Icelanders the biggest consumers of geothermal energy are Indonesia, Japan, and New Zealand. The USA produces the most geothermal power in the entire globe. The first geothermal plant, which was built at "The Big Geysers" in California in 1960 and is still in operation today, is doing well. The biggest geothermal energy plant in the world, with a capacity of 1800 MW, is being operated by the California Energy Commission (CEC) to efficiently meet the electrical needs of North California's 10,000,000 household units [11].

The earth's internal heat source presses on the surface, causing geodynamic and geothermal phenomena such as magnificent volcanoes, hotspots, hot springs, hot dry rocks, and fumaroles, among others. The heat inside the globe, according to studies from Utah University [12], is half the reason land rises above sea level or higher to produce mountains. Rock in the upper mantle, ocean crust, and continental crust expands under the pressure of heat, losing density and increasing buoyancy. The crust is being maintained and is not collapsing due to internal heat. While heat is continually created inside, it is not released through the surface at the same pace. Thus, the excess pressure created in this way causes tremors. If this extra pressure can be expelled locally by establishing generators that produce power and harnessing it as electricity, the intensity of the tremor or seismic event can be substantially decreased. It is true that at the moment only about 11,000 MW is being harnessed, which is a tiny portion of the total heat that is produced within the earth (44.2 TW), but the percentage of the heat energy that causes the seismic event is also insufficient, or 0 [13].

Conclusion

The weaker areas along the line of fault and even the middle of the plates are pierced and punctured by the excessive pressure of the geothermal power. We logically support our theory using the facts and statistics from the data and seismic incidents that were mentioned in depth above. Additionally, it is doubtful if deep-focus earthquakes with hypocenters as far under the surface as 700 km are even possible given that the lithosphere's plate thickness is just 100 km. It is impossible to explain how such earthquakes happen in terms of the release of stress and strain accumulated along the lithosphere's plate borders. We cannot refer to these earthquakes as mechanical energy release occurrences. These volatile explosions caused by the melting and boiling of subduction plate pieces are undoubtedly geothermal energy discharge phenomena.

The findings and conclusions made in this study are fairly broad and don't just apply to the Indian subcontinent. The results apply to the whole geo-dynamics, subject to the type of fault lines, since the point of origin of geothermal energy production is spherically symmetrical and the structure of the mantle's upper layer and the lithosphere is relatively similar across the world. It is believed to be nearly impossible to influence the trajectory of natural events, but based on our research and the California Geysers report, we are persuaded to make the outlandish claim that using geothermal energy, at least in a few opted-for natural geothermal regions, to generate electricity and heat homes can lessen the impact of disasters such as tsunamis, earthquakes, and volcanism. Therefore, capturing the excess pressure of geothermal power as electricity and other forms of energy is essential for dealing with the worsening energy crisis and for managing seismic disasters.

The best way to generate sustainable and renewable energy, as well as a replacement for other energy sources, particularly coal and fossil fuels, is through geothermal energy. Given that it produces so little greenhouse gas emissions, this source is safe for the environment. Even though it isn't employed entirely because of issues like location and high expenses, it will end up being the least expensive method of power generation in the future when these conventional fuels start to run out. Although the initial outlay is very high, the long-term savings and efficiency far outweigh that. It has cheap operating costs since it uses no fuel to generate electricity, saving 80% in comparison to fossil fuels. Because geothermal energy and earthquakes are correlated, we may infer that the earth's crust would be less trembling if we could release this extra energy (0.01%). Electricity production is the best way to manage energy.

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References

1. JT Edward, KL Frederick. Earth: An Introduction to Physical Geology, Prentice Hall Inc., New Jersey; c1996.
2. JT Edward, KL Frederick. Earth: An Introduction to Physical Geology, Prentice Hall Inc., New Jersey; c1996.
3. Alfè D. *et al.* Philosophical Transactions of the Royal Society. 1795;360:1227.
4. Bertani Ruggero, Geothermal Power Generation in the World 2010-2014 Update Report, Proceedings World Geothermal Congress 2015 Melbourne, Australia; c2015 April 19-25.
5. Editorial, Quake after-effects, Nature Geoscience. 2013 August;6:585.
6. Proceedings of World Congress on Natural Disaster Mitigation, organized by Institution of Engineers (India); c2004 February 19-22.
7. Geothermal Atlas of India by Geological Survey of India 1987 & 1991 edition.
8. Chandrasekhram D, *et al.* IBC Conference, Manila, Philippines, Proceedings World Geothermal Congress, Kyushu-Tohoku, Japan, May 28 -June 10; 2003. International Geothermal Conference, Reykjavík, Sept. p15; 2005. Proceedings World Geothermal Congress, Antalya, Turkey; c2000 April. p. 24-29.
9. S Ravi. Geo. Surv of India, Spec. Pub. 1996;45:1.
10. Chandrasekhram D, *et al.* IBC Conference, Manila, Philippines; Proceedings World Geothermal Congress, Kyushu -Tohoku, Japan, May 28 -June 10; 2003. International Geothermal Conference, Reykjavík, Sept. p15; 2005. Proceedings World Geothermal Congress, Antalya, Turkey; c2000 April. p. 24-29.
11. California Energy Commission (CEC) Final Report, Integrated High Resolution Micro- earthquake Analysis and Monitoring for Optimizing Steam Production at The Geysers Geothermal Field, California; c2004. http://quake geo.berkelev.edu
12. Hasterok D, Chapman DS. J Geophys. Res. 2007;112:B06415.
13. W Lowrie. Fundamentals of Geophysics, Cambridge University Press; c1997. p. 179.
14. Kapoor SP, Chauhan BC. Univ. Journal of GeoSc. 2014;2(5):141.