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Harnessing Geothermal Energy As Alternative Source of Energy.

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Abstract: Global warming and environmental degradation is a major problem facing our planet. The burning of fossil fuels emits a large amount of carbon dioxide into the atmosphere. The greenhouse gases emitted into the atmosphere causes depletion in the ozone layer resulting in global warming. There are various sources of alternative energy; these include Solar Power, Nuclear Power, Hydroelectric Energy, Wave Energy, Biofuels, Natural Gas, Geothermal Power, Wind Energy, Biomass Energy, Tidal Energy. Geothermal energy is the energy contained in the interior of the earth crust and is enormous among the various renewable energy sources. Geothermal energy is known to be one of the clean energy without smoke and adverse environmental hazard; it stands a major distinction among others due to its availability regardless of the time of the day. Most developed countries have started harnessing geothermal energy as alternative source of energy for heating buildings, direct use and electricity generation. The United State has the highest global electricity generation from geothermal energy making up to about 28% of the global geothermal energy generation. Geothermal Energy made up about one third of the national generation for countries like Philippine and Iceland while Kenya has geothermal electricity generation of about half of its national electricity generation. Inspite of its advantage, geothermal energy has its disadvantages as well but could not be compared to the use of fossil fuel and other alternative source of energy.

Keywords: Geothermal Energy, Alternative Energy, Renewable Energy, Electricity generation

INTRODUCTION

The world population has been increasing with a rise in energy consumption; average per person energy usage has seen increase to 15 times between 1850 and 2010 (Mikkelsen, 2015). This rise in energy consumption has made it more difficult for fuel to be accessed leading to a need to find stable energy sources that are sustainable and economical (Mikkelsen, 2015). A large population in the world is still not being serviced with energy needs at the minimum level even in the 21st century(Ngala, 2015).

Energy plays the most vital role in the economic growth, progress and development as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all country today. Future economic growth crucially depends on the long term availability of energy from sources that are affordable, accessible and environmental friendly (Abraham and Nkitnam 2017). European over dependent on the Energy of Russia is a big issue as regards the sanctions placed on the invasion of Ukraine by Russia which could not be enforced fully because its lack reliable alternative sources of Energy.

The potential issue surrounding the use of fossil fuels, particularly in terms of climate change, was considered by a Swedish scientist named Svante Arrhenius who first state that the use of fossil fuel could contribute to global warming, way back in 1896. The issue has become a hot-button topic over the course of the last few decades. Today, there is a general shift towards environmental awareness and the sources of our energy are becoming under scrutiny. This has led to the rise of a number of alternative energy sources. While the viability can be argued, they all contribute something positive when compared to fossil fuels. Lower emissions, lower fuel prices and reduction of pollution are all advantages that the use of alternative fuels can often provide (Renewable resources Coalition, 2016). Alternative energy is energy source that is an alternative to fossil fuel. Some of these are: Solar Power, Nuclear Power, Hydroelectric Energy, Wave Energy, Biofuels, Natural Gas, Geothermal Power, Wind Energy, Biomass Energy, Tidal Energy and Hydrogen Gas (Renewable Resources Coalition, 2016 and Wikipedia, 2019)

The benefits of this alternative Energy alleviate many of the problems caused by fossil fuel usage particularly when it comes to emissions. However, the advancement of some of these technologies has been slowed down due to the amount of investment needed to make them viable.

THE NEED FOR ALTERNATIVE SOURCES OF ENERGY

Fossil fuels are non-renewable and require finite resources, which are dwindling because of high cost and environmentally damaging retrieval techniques. So the need for cheap and obtainable resources is greatly needed.

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Geothermal energy has emerged as viable alternate energy source that has the potential to significantly reduce the use of fossil fuel (Mikkelsen, 2015).

GEOTHERMAL ENERGY

Geothermal energy is thermal energy generated and stored in the earth. Ninety nine per cent of the earth's volume has temperatures over 1,000°C, with only 0.1 per cent at temperatures less than 100°C (Bayer et. al., 2016). Thermal energy is the energy that determines the temperature of matter. The Geothermal energy of the earth's crust originates from the original formation of the planet and from radioactive decay of materials (is currently uncertain but roughly equal proportions). Geothermal energy is clean energy source that exploits underground heat lift over from the molten rocks (Metcalfe, 2019). Geothermal Power is cost effective, reliable, sustainable and environmentally friendly (Wikipedia, 2019).

GEOTHERMAL ENERGY TECHNOLOGIES

Geothermal energy technologies includes the following
1. Geothermal Electricity Production .Generating electricity from earth's heat.
2. Geothermal Direct use. Producing heat directly from hot water within the earth.
3. Geothermal heat Pump. Using the shallow ground to heat and cool building.
(**Source:** Lund, 2019)

GEOTHERMAL POWER

Geothermal Power is power generated from geothermal energy. Geothermal power is considered to be a sustainable, renewable source of energy because the heat extraction is small compared with the Earth's heat content (Raybach, 2007). The greenhouse gas emission of geothermal electric stations are on average of 45 grams of carbon dioxide per kilowatts-hour of electricity, or less than 5% of that conventional coal - fired plants (Moomaw et.al, 2011).

ENVIRONMENTAL BENEFITS OF GEOTHERMAL ENERGY

Geothermal energy reduces greenhouse gas emissions by at least 90% demonstrating the significant impact geothermal energy can have on fossil fuel consumption (Mikkelsen, 2015).

ECONOMIC BENEFITS OF GEOTHERMAL POWER

Despite the many environmental benefits associated with geothermal plants like the reduction of carbon emissions and environmental pollution, there are numerous direct economic benefits. About half of geothermal plants operate on public lands generating revenue for state, municipal and federal governments. Geothermal plants employ a vast diversity of workers from conception to completion. Lastly, they can be engineered to be a firm or flexible power source (Matek and Gawell, 2014). Economic savings for example, in a house of about 150 to 180 square meters, the economic savings involved is 70% (Solar Energy, 2019).

ADVANTAGES OF GEOTHERMAL ENERGY

Geothermal energy is generally considered environmentally friendly. The carbon footprint of a geothermal power plant is minimal (An average geothermal power plant releases the equivalent of 122 kg CO_2 for every megawatt of {MWh} of electricity and it generates-one eight of the carbon emissions associated with a typical coal power plants).
Geothermal reservoirs come from natural resources and are naturally replenished. Geothermal energy is therefore a renewable energy source.
Worldwide energy consumption-about 15terawatts (TW) – is not anywhere near the amount of energy stored in earth.
Geothermal energy is a reliable source of energy. The power output of a geothermal power plant can be predicted with accuracy. It has high efficiency
Promotes national Unity.
No sound pollution
Geothermal Energy has high efficiency and low consumption
(**Source:** Energy Informative, 2019; Conserve Energy Future, 2019; Solar Energy, 2017 and Ayres, 2016)

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DISADVANTAGES OF GEOTHERMAL ENERGY

High initial investment cost in constituencies the facilities and infrastructure will be built and high risk of proving the resources

Potential Emission - Greenhouse gas below Earth's surface can potentially migrate to the surface and into the atmosphere. Such emission tends to be higher near geothermal power plants, which are associated with sulfur dioxide and silica emissions. Some reservoir can contain traces of toxic heavy metals including mercury, arsenic and boron. However, the amount of gas emitted is lower than that for fossil fuel.

Surface Instability - Construction of Geothermal plant can affect the stability of land which can give rise to earthquake.

Possibility of Depletion of Geothermal Sources – Furthermore, despite being considered a sustainable and renewable energy, the chances are that specific location might cool down after a long time making it impossible to harvest more geothermal energy in future. The only non depletable option is sourcing geothermal energy from magma but the technology for this is still in process.

Land requirements for geothermal system to be installed - In case of geothermal systems, having a piece of land next to the house is required in order to be able to install one. That makes it impossible to be implemented for homeowners in big cities, unless a vertical ground source heat pump is used.

Suited to a particular region – it's hard to find remarkable geothermal reservoirs just anywhere. Geothermal energy account for about one – third of Iceland and Philippines' electricity needs. Good site for geothermal energy generation occur far away from cities

It requires extremely high temperatures about 350^{o}F and is set up where temperature below earth's surface are high and steam production possible be continuous.

(**Sources:** Meyers, 2016;; Greenmatch, 2014; Power World Analysis, 2018; Mistra, 2019 and Conserve Energy Future, 2019)

GLOBAL INSTALLED GEOTHERMAL ELECTRICITY CAPACITY

From table 1 and 2 and also figure 1 and 2, the United States has maintained a steady growth in geothermal energy and this has contributed 0.3% to its share of National energy generation. Philippine has geothermal as 27% of its national electricity generation. Kenya depends majorly on geothermal energy since it contributes about 51% to its share of national energy generation. Indonesia, Italy, Iceland and Turkey were increasing in their yearly geothermal electricity generation. Philippine and Iceland have geothermal electricity generation to be about one-third of their national electricity generation. Geothermal electricity generation constitute about half of the national generation for Kenya. Also, from the table 1 and figure1 below it could be observed that the yearly geothermal energy generation for some developed countries increases, others maintain their capacity generation while others falls each year. From table 3 and figure 2, total geothermal energy generation has maintained a steady increase from 2007 to 2021.

CONCLUSION AND RECOMMENDATION

The presence of geothermal resources and their utilization can be important factors in creating a sense of place. The Earth's geothermal heat content is enormous, 99% of earth's volume has temperatures greater than 1000^{o}C, and only 0.1% of this volume is at temperature less than 100^{o}C. Society is just beginning to tap the immense potential of the Earth's heat to meet some of its energy needs. Sustainable use of geothermal resources requires finding the appropriate level of production for the resources being tapped, which in turn is dependent on the field size, natural recharge rate and other characteristics (Rybach, 2007). Since estimated amount of geothermal energy that could be used is significantly bigger than the total quantity of energy resources based on oil, coal and natural gas put together, geothermal energy should be having more significant impact especially since it is cheap, ecologically acceptable and unlike wind and solar power, geothermal energy is continuously available (Davorh, 2015). So far, geothermal energy hasn't taken off like other renewables. More than a century after humans started using Earth's hot water and steam to produce power, geothermal provides less than 1% of global electricity (Rosen, 2018). Geothermal energy, with its proven technology and abundant resources, can make a significant contribution towards reducing the emission of greenhouse gases and overdependence on fossil fuels but it requires that governments implement policies and proven measures to improve the competitiveness of geothermal energy systems with conventional energy systems. Also, it is considered possible to produce up to 8.3% of the total world electricity with geothermal resources supplying 17% of the world population. Thirty-nine countries (located mostly Africa, Central/South America and the Pacific) could potentially produce 100% of their electricity need using geothermal resources. Therefore, it is recommended as much as possible, an alternative energy source for all nations.

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Table 1: Installed Geothermal Electric Capacity

Countries	Capacity in Megawatts (MW)										Percentage Share of National Generation
	2007	2010	2013	2015	2016	2017	2018	2019	2020	2021	
United States	2687	3086	3389	3450	3567	3591	3639	3676	3714	3722	0.3
Philippine	1969.7	1904	1894	1870	1868	1868	1868	1918	1918	1918	27.0
Indonesia	992	1197	1333	1340	1375	1809	1948	2133	2133	2276	3.7
Mexico	953	958	980	1017	926	951	951	962.7	926.7	962.7	3.0
New Zealand	471.6	628	895	1005	950	980	1005	1005	1005	1037	14.5
Italy	810.5	843	904	916	944	944	944	944	944	944	1.5
Iceland	421.2	575	664	665	665	710	755	755	755	754	30.0
Kenya	128.8	167	215	594	676	676	676	861	861	861	51.0
Japan	535.2	536	537	519	537	542	542	601	603	603	0.1
Turkey	38	82	163	397	775	1100	1347	1526	1526	1710	0.3
Costa Rica	162.5	166	208	207							14.0
El Salvador	204.4	204	204	204							25.0
Nicaragua	79	82	97	82							9.9
Papua New Guinea	56	56	56	50							
Guatemala	53	52	42	52							
Portugal	23	29	28	28							
Russia	79	79	82	82							
China	27.8	24	27	27							
Germany	8.4	6.6	13	27							
France	14.7	16	15	16							
Ethiopia	7.3	7.3	8	7.3							
Austria	1.1	1.4	1	1.2							
Australia	0.2	1.1	1	1.1							
Thailand	0.3	0.3	0.3	0.3							
Total	9,731.9	10,709.7	11,765	12,635.9							

(**Source:** Ruggero, 2007; Holm et. al., 2010; Wikipedia, 2019; Richter,2017:; Richter, 2018,: Richter, 2019: Richter, 2020: Richter, 2021 and Richter, 2022)

Table 2. Top 10 Geothermal Countries in the World Based on installed Capacity

Countries	Capacity in Megawatts (MW)										Percentage Share of National Generation
	2007	2010	2013	2015	2016	2017	2018	2019	2020	2021	
United States	2687	3086	3389	3450	3567	3591	3639	3676	3714	3722	0.3
Philippine	1969.7	1904	1894	1870	1868	1868	1868	1918	1918	1918	27.0
Indonesia	992	1197	1333	1340	1375	1809	1948	2133	2133	2276	3.7
Mexico	953	958	980	1017	926	951	951	962.7	926.7	962.7	3.0
New Zealand	471.6	628	895	1005	950	980	1005	1005	1005	1037	14.5
Italy	810.5	843	904	916	944	944	944	944	944	944	1.5
Iceland	421.2	575	664	665	665	710	755	755	755	754	30.0
Kenya	128.8	167	215	594	676	676	676	861	861	861	51.0
Japan	535.2	536	537	519	537	542	542	601	603	603	0.1

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Turkey	38	82	163	397	775	1100	1347	1526	1526	1710	0.3

Table 3: Global Geothermal Based on Installed Capacity

Capacity in Megawatts (MW)										
	2007	**2010**	**2013**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total	9,731.9	10,709.7	11,765	12,635.9	12700	14060	14600	15406	15608	15854

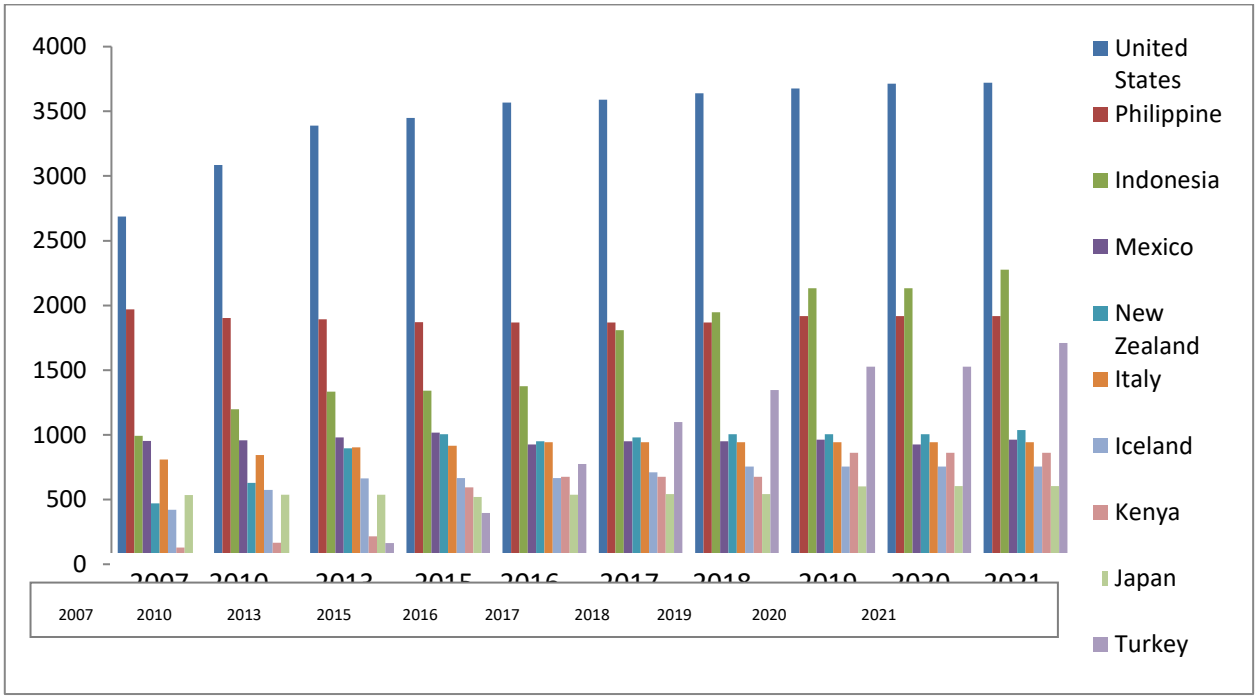

Figure 1. Top 10 Geothermal Countries in the World Based on installed Capacity

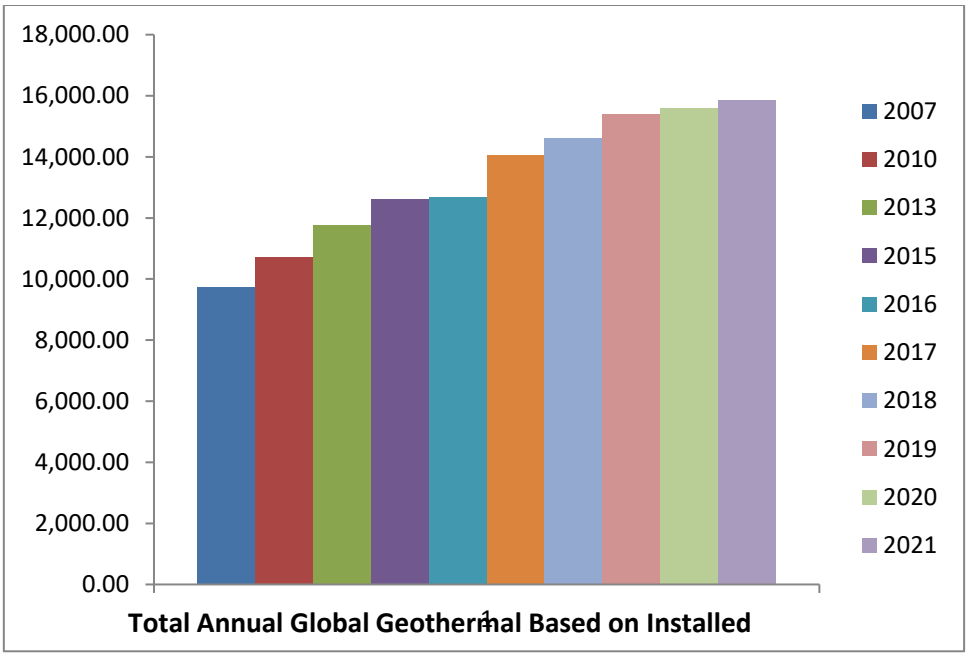

Figure 2: Total Annual Global Geothermal Based on Installed Capacity