Chapter

# Introductory Chapter: Geothermal Energy – Challenges and Improvements

*Zayre Ivonne González Acevedo and Marco Antonio García Zarate*

## 1. Introduction

### 1.1 Outline

In recent years, the issue of energy production has been in the international debate. The discussion has focused on the generation of agreements and actions for the care of the environment, due to the negative impacts that the energy industry, mainly based on fossil fuels, has generated on the planet [1, 2].

The use of natural resources in a more responsible and comprehensive manner has become more relevant. The energy crisis and climate change have pointed to the development of technologies that allow the use of alternative energies with higher performance, efficiency, and less environmental impact. Hence, geothermal energy plays an important role to be used as an alternative energy source, which contributes to the achievement of the Sustainable Development Goals [3]. For example, SDG 7, on affordable, reliable, sustainable, and modern energy for all, SDG 13, on climate action and the Paris Agreement [4]. Being recognized as an ally to solve part of the problem of climate change and distribute electricity at low economic, social, and environmental cost [5].

Among the alternative energies, geothermal energy is the heat energy generated in the interior of the Earth. Under favorable conditions, a small proportion of this energy can be extracted and used by humanity. A geothermal system is the combination of the following elements: a heat source, a fluid that transfers heat, porous and permeable rocks that allow the accumulation of the hot fluid, and impermeable rocks that function as a sealing layer to prevent or reduce the migration of the hot fluid to the surface. The deeper it is the fluid, the higher is its temperature, and according to its enthalpy, it has the capacity to provide direct uses or to generate electricity [6–8].

Geothermal resources have been identified in almost 90 countries, with a record of geothermal utilization in more than 70 countries. As of 2010, electricity from geothermal energy is produced in 24 countries. Nearly 40 countries worldwide are considered to have sufficient geothermal potential that could meet their total electricity demand with geothermal energy, for example, Costa Rica, Ecuador, Guatemala, Indonesia, Iceland, Mozambique, Peru, and the Philippines. While Iceland and El Salvador have the highest share of geothermal energy in their country's energy mix, generating about 25% of their electricity from geothermal resources. The United States and the Philippines have the largest installed capacity of geothermal power plants: approximately 3000 MW and 1900 MW, respectively [9].

## 2. Advantages

The great advantage of the geothermal resource is that its transformation into electricity can be done independently of the weather and a schedule. As is the case of wind and solar energy, playing an important role since it is available 24 hours a day, 365 days a year, allowing continuously feed to the geothermal power plants, which can act as the economic base of a region [10]. In addition to requiring, less land per megawatt produced, compared with solar and wind energy.

This energy resource has many advantages over other alternative energies when Life Cycle is considered in the analysis, such as competitive heat prices, continuous source of energy, and low environmental impacts. Furthermore, the additional valorization of geothermal water through its use for low-temperature heating and the recovery of mineral resources are ways to provide additional benefits to the local communities and/or the developer, in a sustainable environment in the exploitation of the direct and indirect uses of the geothermal resource [11]. To achieve this, a clear energy policy is needed in the countries, between the developer, government, and communities. The lack of commitment and enthusiasm of governments weakens the potential growth of the sector to be developed by private sector investment or foreign investors, to activate the production and improve the productivity of geothermal energy [12].

## 3. Challenges

One of the challenges of geothermal energy is that it is closely linked to the geological structures present in active volcanic areas, in areas with geological faults and areas with seismic activity, which represents the uniqueness of the resource. Its extraction is a challenge, which signifies the need to improve exploration and exploitation techniques to access deep resources and avoid negative impacts on the environment. However, due to its nature, it has several opportunities for technological development and productive processes for human development with direct uses of geothermal heat or geothermal power plants [13].

Despite that, geothermal energy is an alternative source of electricity, it is sometimes considered as a renewable energy (when extraction does not exceed recharge) [14], a sustainable energy (when production rates are maintained for more than 40 years) [15], and a clean energy (when $CO_2$ concentrations emitted are below the local limits) [16]. However, it can cause negative impacts on the environment, which sometimes trigger social conflicts.

Nowadays, it is known that environmental conflicts caused by the execution of geothermal projects introduce new variables between the developer, the government, and the communities [17]. Therefore, it is important to solve conflicts related to this natural resource. Through mediation between key actors, or by proposing management strategies for geothermal projects, which need a high level of acceptance by the inhabitants of the surrounding area, being the local factor crucial to minimize the socioeconomic impact and promote social acceptance.

*DOI: http://dx.doi.org/10.5772/intechopen.109190*





## Author details

Zayre Ivonne González Acevedo* and Marco Antonio García Zarate
Center for Scientific Research and Higher Education at Ensenada (CICESE),
Baja California, Mexico

*Address all correspondence to: zgonzale@cicese.mx

## References

[1] Martins F, Felgueiras C, Smitkova M, Caetano N. Analysis of fossil fuel energy consumption and environmental impacts in European countries. Energies. 2019;**12**(6):964

[2] Solarin SA. An environmental impact assessment of fossil fuel subsidies in emerging and developing economies. Environmental Impact Assessment Review. 2020;**85**:106443

[3] Majid MA. Renewable energy for sustainable development in India: Current status, future prospects, challenges, employment, and investment opportunities. Energy, Sustainability and Society. 2020;**10**(1):1-36

[4] Sachs JD, Schmidt-Traub G, Mazzucato M, Messner D, Nakicenovic N, Rockström J. Six transformations to achieve the sustainable development goals. Nature Sustainability. 2019;**2**(9):805-814

[5] Byrne JA, Lo AY, Jianjun Y. Residents' understanding of the role of green infrastructure for climate change adaptation in Hangzhou, China. Landscape and Urban Planning. 2015;**138**:132-143

[6] Barbier E. Geothermal energy technology and current status: An overview. Renewable and Sustainable Energy Reviews. 2002;**6**:3-65

[7] Bruni S. La Energía Geotérmica en una nueva serie sobre la innovación de energía. Centro de Innovación Energética (CIE). Washington DC, USA: Departamento de Infraestructuras y el Medio Ambiente, Banco Interamericano de Desarrollo (BID); 2014. pp. 1-10

[8] Nicholson K. Geothermal Fluids: Chemistry and Exploration Techniques. Springer Science & Business Media; 2012

[9] Gehringer M, Loksha V. Geothermal Handbook: Planning and Financing Power Generation. ESMAP Technical Report 002/12. Washington DC, USA: World Bank; 2012

[10] Tomaszewska B, Pająk L, Bundschuh J, Bujakowski W. Low-enthalpy geothermal energy as a source of energy and integrated freshwater production in inland areas: Technological and economic feasibility. Desalination. 2018;**435**:35-44

[11] Shortall R, Davidsdottir B, Axelsson G. Geothermal energy for sustainable development: A review of sustainability impacts and assessment frameworks. Renewable and Sustainable Energy Reviews. 2015;**44**:391-406

[12] Huttrer GW. Geothermal power generation in the world 2015-2020 update report. In: Proceedings World Geothermal Congress. Vol. 1. 2020. p. 15

[13] Soltani M, Moradi Kashkooli F, Dehghani-Sanij AR, Nokhosteen A, Ahmadi-Joughi A, Gharali K, et al. A comprehensive review of geothermal energy evolution and development. International Journal of Green Energy. 2019;**16**(13):971-1009

[14] Stefansson V. The renewability of geothermal energy. In: Proceedings World Geothermal Congress 2000 Kyushu - Tohoku, Japan. May 28 - June 10, 2000. pp. 883-888

[15] Rybach L. Geothermal energy: Sustainability and the environment. Geothermics. 2003;**32**:463-470

[16] González-Acevedo ZI, García-Zarate MA. Geothermal energy as an alternative to reduce atmospheric emissions and provide green energy.

In: Green Technologies to Improve the Environment on Earth. London, UK: IntechOpen; 2018

[17] Gabo-Ratio JA, Fujimitsu Y. Exploring public engagement and social acceptability of geothermal energy in the Philippines: A case study on the Makiling-Banahaw geothermal complex. Geothermics. 2020;**85**:101774