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Geothermal Energy Country Update, Iran

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ABSTRACT

During the last few years, there has been a renewed interest in renewable energy development in Iran, resulting in a significant change in the power generation matrix. This paper provides a summary of geothermal activities in Iran with an emphasis on developments for 2020-2023. Iran has a wide variety of low to high-enthalpy resources that are substantially associated with volcanic provinces. In this paper, we present advancements in geothermal power and direct-use projects in Iran. A 5 MW Meshkinshahr project for power generation from the Sabalan geothermal field at the Ardabil Province, at NW of Iran, is in the final stage. As a current plan, it was planned to be in operation in the summer of 2022 but because of some reasons, it is postponed to next summer. Direct utilization of geothermal fluids for swimming, bathing, and balneological applications of hot springs is about 139.76 MW around the country, which are the most outstanding hot springs around the country. Also, some other direct use applications such as fish farming are starting to be utilized in some areas in the last years. Geothermal heat pumps for cooling and heating are starting with some new vertical and horizontal ground loop projects. Scientific attention to thermal energy extraction from abandoned oil and gas wells is another promising area of interest, because there are more than 2500 abandoned wells in Iran widely distributed around the country. Energy in those wells can be used for power generation, water desalination, industrial uses, and building heating. Its huge potential can be used in the future years.

1. INTRODUCTION

Today, not only development but also the continuation of life requires energy. This energy is provided through various carriers, such as oil, gas, coal, and renewable energies. Providing energy in a country like Iran with a vast geography and different climatic conditions, such as variations in altitude and climate and social issues, requires precise and scientific planning in this field. But in recent years, the planning has been followed by assigning a high share to natural gas without considering national interests and management considerations in energy optimization.

One of the reliable and efficient ways to supply energy is to use geothermal energy. Geothermal energy is low-risk, long-lasting, safe, reliable, and brimming with untapped potential. It is always available, has little impact on the landscape, and is versatile. It can even be used for cooling and heating and to create more jobs than any other green energy. Geothermal energy is the natural heat hidden inside the earth, which is due to the remaining heat in the earth's core since its formation and to the radioactive decay of minerals in rocks of the lithosphere. Similar to other renewable energy resources, geothermal energy has availability and local accessibility. Experience has shown that the temperature increases with depth [1], approximately 3°C for every 100 meters in average. The temperature in the lower lobes of the earth's crust is 1300°C and in the central core is about 5000°C. However, in some areas of the earth's crust, higher temperatures can be reached and this available energy can be used optimally. Some estimates show that 1% of the heat available in the first 10 km of the earth's crust is equivalent to 500 times the energy available in all the oil and gas resources on earth [2]. The main advantages of geothermal energy are:

- It is renewable.
- It is reliable.
- It is constant and predictable.
- Low emissions.
- No fuel is required.
- Environmentally friendly.
- There is a massive reserve of energy.
- It is versatile.
- It creates local jobs.
- Itis an indigenous source.
- It is scalable.

In this paper, an overview of recent developments in geothermal energy in Iran is presented. We will focus on power generation and the direct uses, particularly geothermal heat pumps.

2. PREVIOUS WORKS

Since 1975, numerous studies have been made in order to identify the geothermal potential in Iran, by the Ministry of Energy in cooperation with the Italian company ENEL, particularly in the north and northwest areas of Iran, over an area of 260,000 square kilometers. The result of these studies indicated that the Sablan, Damavand, Khoy-Maku, and Sahand regions, with an area of 31,000

km^2, are suitable for conducting additional geothermal surveys, which were carried out in 1982. With the completion of preliminary exploration studies in each of the mentioned areas, the areas of interest were identified more accurately. As a result of these studies, Meshkinshahr, Sarein, and Busheli areas were selected in the Sablan region, the Nondal area in the Damavand region, the Siah Cheshme and Qotour areas in the Maku-Khoy region, and five smaller regions were selected in the Sahand region to focus the activities of the supplementary exploration phase. After a relatively long break because of the Iran-Iraq war, the project was reactivated and the existing investigation reports were reviewed by the UNDP experts again in 1990, and the Meshkinshahr geothermal area was considered as the first priority for continuing exploratory studies. Following the mentioned studies, the the drilling of the first geothermal well started in 2002. The first phase of this project was completed in 2013, with three exploratory and two injection wells drilled, and two production tests of the exploratory wells were successfully completed. The most important achievement of this phase of the project was the acquisition of technical knowledge related to drilling geothermal wells.

The second phase of this project started in 2014 [3] and a total of 8 additional production wells were drilled and tested, with an average wellhead fluid temperature of about 190°C.

Mousavi et al. [4] published a geothermal country update report on Iran for the years between 2015 to 2020. In this report, they tried to give a summary of the main geothermal energy projects under study or implementation in Iran. They declared that with huge thermal tourism capacity potential in Meshkinshahr and Sarein, the target is to increase the number of domestic and international visitors to 5 million and 250,000 people by the year 2025, respectively.

The most outstanding study in the field of geothermal energy potential assessment was implemented by Yousefi et al. [5]. Through this research, they developed the latest geothermal resources map of Iran. For instance, 18 promising geothermal areas were defined, but not ranked. The results indicate that about 144,815 km^2 (8.8%) of the Iran territory is described as a potential geothermal area. In addition to the already-known thermal areas, this geothermal potential survey revealed several other high-potential geothermal prospects, which are shown in Figure 1.

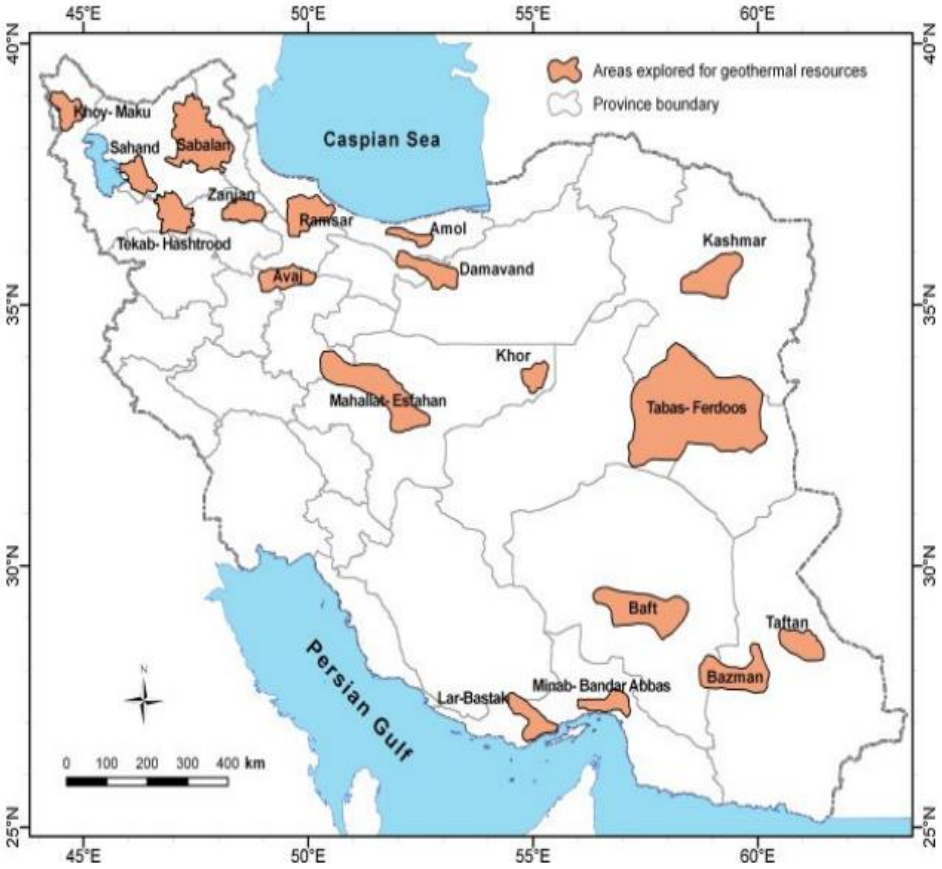

Figure 1: Geothermal resources map of Iran [2].

2. POWER GENERATION

Major energy production in Iran is mainly done through fossil energy sources. This is because Iran is one of the most important countries in terms of oil and gas energy resources. However, severe environmental problems caused by the use of fossil fuels have drawn attention to the use of renewable energy sources in recent years. At present, renewable energies have developed well in the world, and under these conditions, 895 MW of renewable power plants (mostly solar and wind) have been developed in Iran, which represents about 1% of Iran's total electricity production. The new government has paid great attention to the development of renewable energy in Iran and has passed important supportive laws for this purpose. In this regard, the Renewable Energy and Energy Efficiency Organization of Iran (SATBA) have recently held large tenders for the construction of large-scale renewable power plants. However, the development of geothermal energy in Iran has been slow until now. The most important reason for this, is the lack of

knowledge of the economic potential of geothermal energy in Iran by the private and public sectors, and also the international sanctions. Table 1 shows the present and planned production of electricity in Iran from different energy resources.

Table 2: Present and planned production of electricity in Iran from different energy resources

	Geothermal		Fossil fuels		Nuclear		Hydro (Small and large)		Other renewable (wind, solar, and biomass)		Total	
	Capacity (MW)	Gross prod. (GWh/yr)	Capacity (MW)	Gross prod. (GWh/yr)	Capacity (MW)	Gross prod. (GWh/yr)	Capacity (MW)	Gross prod. (GWh/yr)	Capacity (MW)	Gross prod. (GWh/yr)	Capacity (MW)	Gross prod. (GWh/yr)
In operation	0	0	73630	287483	1000	6132	12442	31082	983	1085	88055	325782
Under construction	5	39.4	10000	74000			200	260	4000	6280	14255	--
Funds committed, but not yet under construction	50	394	5000	37000			-	-	1000	650	1055	
Total projected use	55	433.4	45568	209612	1000	6132	11296	30072	637.75	1696.415	58602	

3. DIRECT USE OF GEOTHERMAL ENERGY

Figure 2 describes the different forms of geothermal energy with reference to the depth of resources and their final use [6]. Direct use of geothermal is one of the most common and developed methods of using this energy, which has a long history in Iran. As shown in Figure 1, geothermal energy sources are spread throughout Iran and can be used in many parts of the country.

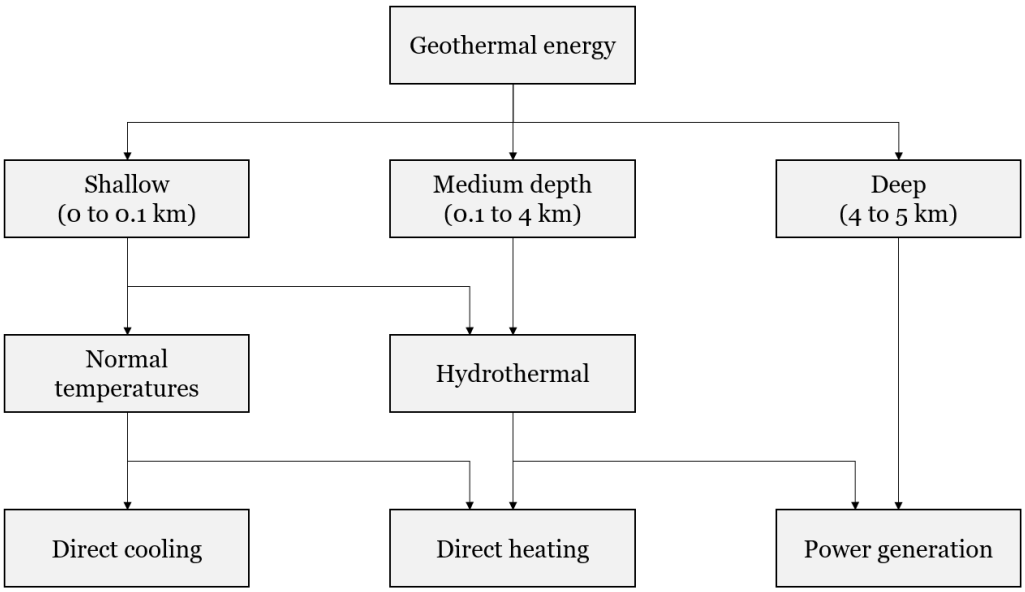

Figure 2: Different forms of geothermal energy with reference to the depth of resources and their final use.

Currently geothermal heat capacity for use in direct applications in Iran is 141.129 MW_{th}. The main uses are balneotherapy and recreation. The total heat production is 533.586 GWh/year, which is about 10% of the full capacity and 20% of the total heat production in direct geothermal uses in Iran. Recreation is one of the most promising fields of geothermal energy application in Iran [7].

Direct uses of geothermal energy also include hot water pools, greenhouses, home heating, snow melting and frost prevention, and heat pumps. . The use of geothermal energy for greenhouses not only reduces the costs of using fossil fuels but also creates a stable temperature in the greenhouse and prevents environmental pollution caused by these fuels. With the help of piping and pumps, hot waters can be transferred to residential areas, and use the heat for heating households. For using geothermal fluids for snow melting, systems with pipes embedded in networks are used, and the fluid heated by geothermal resources is sent into the pipes to melt the snow. Geothermal heat pumps are mentioned in the next section. The summary of the direct use of geothermal energy in Iran is presented in Table 2[8].

Table 2: Summary of direct geothermal use in Iran.

No.	Type of Direct Use	Capacity (MW)	Energy used (GWh/year)	Capacity factor
1	Balneology and swimming pools	139.764	523.586	0.43
2	Aquacultural use	1.004	7.04	0.8
3	Heating and cooling by heat pumps	0.361	2.96	0.82
4	**Total**	**141.129**	**533.586**	

4. GEOTHERMAL HEAT PUMPS

Renewable-based heating and cooling systems are usually not able to provide comfortable conditions alone, and need to be utilized in combination with auxiliary systems. In the design of these systems, a heat pump is often used to avoid the use of fossil fuel combustion equipment. Since heat pumps work without producing polluting gases, in recent years they have been widely used in central units, independently or combined with renewable energies such as solar energy and other geothermal resources.

A serious study on geothermal heat pumps started in 2013, in the deputy energy affairs department of SATBA organization in Iran. These studies led to the conversion of air conditioner devices into geothermal heat pumps (GHP). This devices have been installed and operated in the geothermal site of Meshkinshahr and its ground coil, which is horizontal, has reduced its electricity consumption by 30%. To complete its studies, this organization, with the help of a private company, prepared four geothermal heat pumps and tested them in the laboratory. The results showed a significant reduction in electricity consumption compared to conventional air conditioners [9].

The next efforts in this field, led to the installation and operation of geothermal heat pumps in the cities of Tehran, Mashhad, Qom, Kashan, Taleghan, Rasht, Ahvaz, and Bandar-Abbas, with a total installed capacity of 361 kW. Table 3 shows the characteristics of these projects [10].

Table 3: A summary of the characteristics of geothermal heat pumps in 16 locations in Iran

Location	Capacity (kW)	Coil type	Heating	Cooling	Energy supplied area (m^2)
Metsap research lab. University of Tehran	3.5	Spiral with Fin	✓	✓	45
The Center for Progress and Development (CPDI) of Iran Presidency-Satarkhan Building	23.0	Vertical + Spiral	✓	✓	279
Tehran municipality-D1 (Mehreghan park)	14.5	Vertical	✓	✓	120
Tehran Municipality-D22	17.5	Vertical	✓	✓	150
Tehran Municipality-D11	10.0	Vertical	✓	✓	50
VardAvad Substation (Tehran)	157.0	Vertical	✓	✓	1200
Mashhad (Abfa)	21.0	Vertical	✓	✓	220
Kashan University	6.0	Vertical	✓	✓	240
Qanavat (Qom)	35.0	Vertical	✓	✓	300
Jemezghan (Qom)	30.0	Vertical/Open	✓	✓	230
Salarieh (Gas office Qom)	6.7	Slinky	✓	✓	50
Meshkinshahr	5.0	Horizental	✓	✓	24
Taleghan	20.5	Vertical/Slinky	✓	✓	165
Rasht	5.0	Horizontal-Vertical	✓	✓	50
Ahvaz	5.0	Slinky	✓	✓	45
Bandar-Abbas	5.0	Slinky	✓	✓	50
Total capacity (kW)	**361.2**				**3173**

5. OUTLOOK FOR THE FUTURE

Iranian government and decision-makers believe that geothermal hot waters provide a reliable, clean, sustainable source of energy, which can be effectively used for recreational, agricultural and aquaculture purposes, specifically in the northwestern parts of the country. In the sixth national development plan, various strategies with regard to geothermal energy development have been ordered, which are categorized as follows:

- Completion of the 5 MW Sabalan geothermal power plant, which is in the final stage of the installation phase.
- Continuing exploration of four another geothermal prospects in the Sabalan geothermal field (in progress), including reservoir evaluation, field development, environmental study, and drilling further exploratory wells.
- Direct heat utilization development in the northwestern part of Iran, based on more detailed geoscientific surveys, drilling exploratory wells, and improving the present bathing and swimming facilities in Sarein and Meshkinshahr prospects.
- Two more sites (Ramsar and Mahallat in the north and west part of Iran, respectively) have been considered for experimental greenhouse, aquaculture, and space heating purposes. The projects have been scheduled for the next 10 years.

6. CONCLUSIONS AND RECOMMENDATIONS

Iran has different weather conditions across the country. Some places have high temperatures and high humidity and some places experience extreme cold. In this situation, geothermal energy can play an essential role in saving energy and supplying space cooling and heating. According to this study, installed geothermal systems have the potential to decrease fossil fuel energy use in the country. In this article, the updated geothermal energy use capacity of the county is reported.

REFERENCES

1. S.K. Sanyal, Sustainability and renewability of geothermal power capacity. In: L.Y. Bronicki (Eds), Geology and Hydrology of Geothermal Energy. pp 47-60. Springer, New York, NY. 2018.

2. S.K. Sanyal, J.W. Morrow, S.J. Butler, and A. Robertson-Tait. Cost of electricity from enhanced geothermal systems. ThirtySecond Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, January 22-24. 2007.

3. Younes. N., Shahab. E., Davood N.: Geothermal Direct Use in Iran: A Country Update, Proceedings World Geothermal Congress 2020+1, Reykjavik, Iceland, April - October 2021

4. Seyed Zahed M., Saeid J.: Geothermal Country Update Report of Iran (2015-2020), Proceedings World Geothermal Congress 2020+1, Reykjavik, Iceland, April - October 2021

5. H. Yousefi et al., "Developing the geothermal resources map of Iran," Geothermics, vol. 39, no. 2, pp. 140–151, 2010.

6. Morteze K., Hossein A., Samaneh T., Arefeh A.: Enhanced geothermal energy and its position in the world, Journal of Renewable and New Energy, 12, (2019), 42-54

7. Y. Noorollahi, M. S. Shabbir, A. F. Siddiqi, L. K. Ilyashenko, and E. Ahmadi, "Review of two-decade geothermal energy development in Iran, benefits, challenges, and future policy," Geothermics, vol. 77, pp. 257–266, 2019

8. Noorollahi Y, Eslami S, Noorollahi D. Geothermal Direct Use in Iran : A Country Update. Proc. World Geotherm. Congr. 2020+1, Reykjavik, Iceland, April - October 2021: World Geothermal Congress 2020; 2021, p. 1–10

9. Abdolmahdi H., Amirhossein H., Mohammad T.: Design, Manufacture and Analysis of a Geothermal Heat Pumps. JEM 2017; 7 (1) :48-59 URL: http://energy.kashanu.ac.ir/article-1-564-fa.html

10. Taghaddosi M, Porkhial S. Geothermal Heat Pump in Iran. Proc. World Geotherm. Congr. 2015, Melbourne, Australia, 19-25 April 2015: 2015