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Geothermal Energy in Iran

Soheil Porkhial[1,2] , Parisa Yousefi[2]

[1,2]Renewable Energy Organization of Iran (SUNA), Energy Building, Pazhouheshgah-e Niroo, Pounak Bakhtari Avenue

Shahrak Ghods, Tehran, Iran

1-Porkhial@iranenergy.org.ir, 2- parisa.yousefi48@yahoo.com

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ABSTRACT

Activities in the field of geothermal energy in Iran are focused on scientific and research aspects, and the research part is aimed at reduction of capital required for exploitation of related resources. The second step is to work research results into scientific dimension of this field for practical means, i.e. establishing electricity power plants and direct uses. At the moment, projects assuming 5 MWe of geothermal power plants are underway. Based on the planning in the 4th Socioeconomic and Cultural Development Plan (2005–2010), the private sector is expected to have a share of at least 500 MWe in renewable energies. However, it is the government's duty to take the first step for investment in geothermal energy. The project of Iran's renewable energy, aims to accelerate the sustainable development of geothermal energy through investment and removal of barriers.

The potential of geothermal development in Iran is large in terms of moderate, low and high temperature. A distribution map of potential areas for geothermal resource in Iran have been drawn which shows 14 suitable regions for geothermal activities. Between these 14 regions, Sabalan region seems to have the most considerable resources and Meshkinshahr field also in this region has priority for installation of a geothermal power plant. Surface and drilling exploration and resource assessment have been ended. According reservoir numerical model and feasibility study, 5 MWe power plant for 5 km^2 area was proved. Extension of reservoir has been predicted to 20 km^2 and 250 MWe installed capacity was expected from this field.

1. INTRODUCTION

Due to decomposition of the internal earth's crust elements, huge amount of heat is produced. At the most subterranean layers of the earth, the temperature increases so high that stones and soils are melted. If underground flowing water passes in close vicinity, it becomes hot. The geothermal resources are not the same everywhere and these resources mostly exist wherever there is a volcano.

Geothermal energy is classified as direct use (heating) and indirect use (electricity) energy. Direct heat use is one of the oldest, most versatile and also the most common form of utilization of geothermal energy. This method is mostly used in the countries like Iceland, USA, Hungary, Italy and etc. Another way of using this energy is generation of electricity. Very hot water and vapor is transferred to power plants through pipelines to start rotating and keep on moving turbines. Some of the countries such as New Zealand, Philippines, America, Italy, Japan, Iceland, Turkey, Indonesia, China, etc., have built power plants to generate electricity from geothermal energy. The forecasts of geothermal power were supposed to be at 10,715 MWe (Bertani, 2010).

Geothermal energy is fueled by a resource that is sustainable in economic, social and environmental term. Geothermal energy has the capacity to provide cost-effective energy to remote communities without the added investment of providing fossil generation. The degree to which such efforts will be successful will be driven in part by the existence of geothermal resources and reliable cost-effective technology. Success will also depend on good policy decisions being made. In many cases, compromises are required since options are mutually exclusive. In other cases, carefully considered policy can minimize the conflict between renewable and non-renewable energy.

2. GEOTHERMAL RESOURCES

Interest in the geothermal energy originated in Iran since Mr. James R. McNit , a United Nations geothermal expert visited Iran (December 1974). He reported that Iran has very promising prospects for geothermal energy development. Upon Mr. McNitt's recommendations in 1975, a contract between Ministry of Energy (MOE), ENEL (Entes Nazionale per L'Energia Elettrica of Italy) and TB (Tehran Berkeley consulting Engineers of Iran) was signed for geothermal exploration in northern part of Iran (McNitt, 1974).

Final reports of the regional investigations performed by ENEL for the northern part of Iran were delivered during 1980-1983. According to these reports and investigations of Electric Power Research Center (EPRC), priorities were given to the Sabalan, Damavand, Khoy-Maku and Sahand regions (Figure 1). Such findings were approved by Dr. Valgardur Stephenson (Stephenson, 1989)

The Renewable Energy Organization of Iran (SUNA) as part of Ministry of Energy was done a global investigation in all of Iran during 2000-2002. The investigations approved 10 big areas which have more potentially suitable regions for this purpose. Figure 2 shows these big geothermal prospects of Iran. This first step is useful for showing high potential of hydrothermal potential.

Iran has 32 provinces and SUNA, between 2010 up to now, focused on exploration of geothermal areas in each province according to standard methods. Figure 3 shows the layers which were prepared and integrated for determination of geothermal prospects.

Figure 1. The regions identified by ENEL

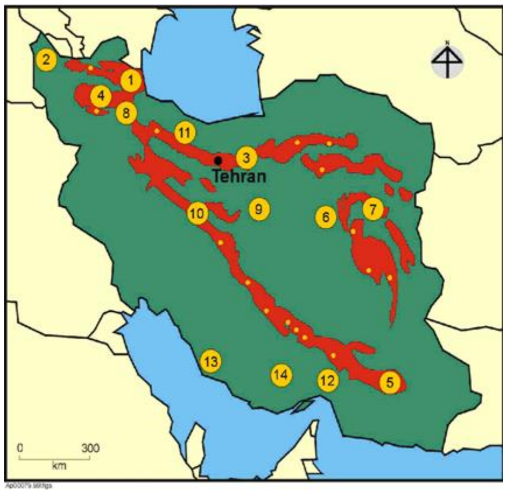

Figure 2. Distribution Map of Potential Areas for Geothermal Resources. 1-Sabalan, 2-Kuoy Maku, 3-Damavand, 4-Sahand, 5- Taftan, 6-Tabas, 7-Ferdos, 8- Takab, 9- Khour Biabanak, 10-Mahalat, 11- Ramsar, 12-Minab, 13-Kazeroon, 14-Lar-Bastak.

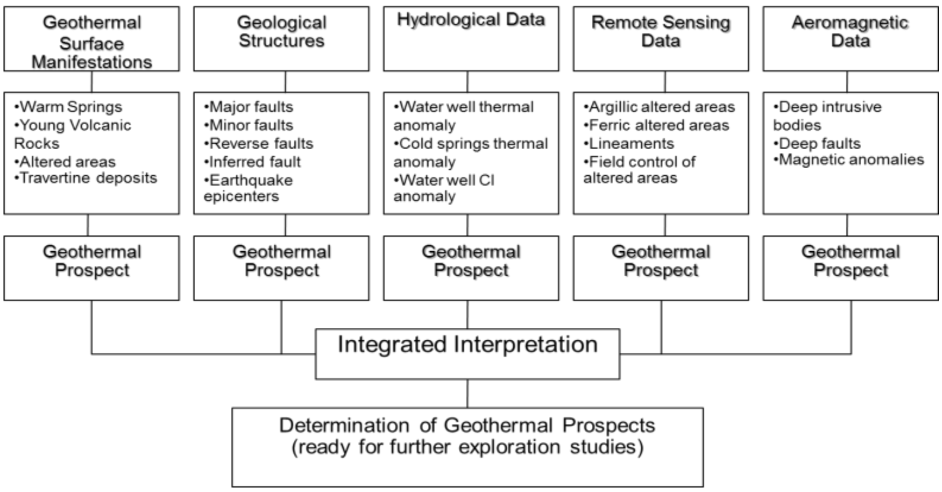

Figure 3. The layers which were prepared and integrated for determination of geothermal prospects

Fig 4 shows the layers and the integrated layer for geothermal prospect for west Azarbaeigan province. Figure 5 shows geothermal prospects areas determined in west Azarbaeijan province.

Figure 6 shows these regions in the IRAN map. We are going do these activities for all of provinces of Iran which have good signs of geothermal. We finished the studies in the Ardebil province and its results are shown in Figure 6. The results of the provinces east Azarbaeijan and south Khorasan will be published soon.

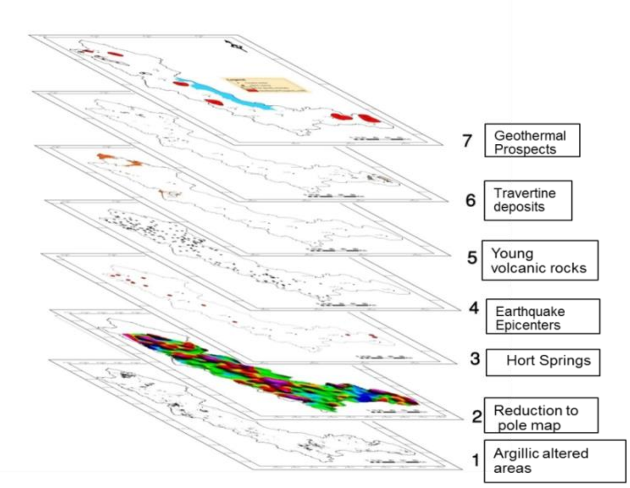

Figure 4. The layers and the integrated layer for geothermal prospects for west Azarbaeigan province

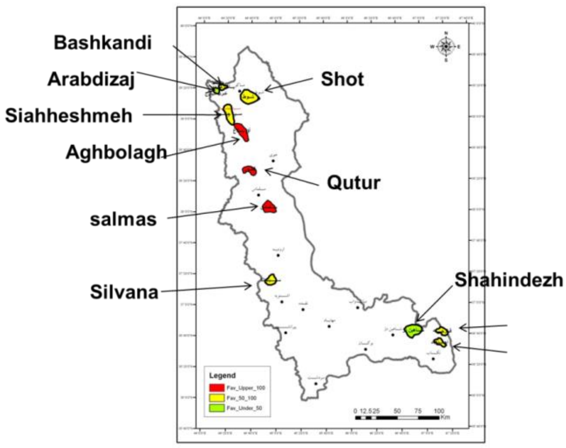

Figure 5. The geothermal prospects areas determined in west Azarbaeijan province.

Figure 6. The geothermal prospects areas which are determined in the Iran Map

3.0 POWER GENERATION

The Sabalan geothermal prospect lies on the western slopes of Mt. Sabalan. The prospect site is located at about 20 km south of the City of Meshginshaar in the Province of Ardebil, in northwestern Iran. The area is located between 38° 12' 52" and 38° 20' 00" North and 47° 40' 30" and 47° 49' 10" East. The Mt. Sabalan geothermal field is located in the Moil Valley on the north-western flank of Mt. Sabalan, in the Ardebil Province of northwestern Iran. Figure 7 shows location of Sabalan field in Iran.

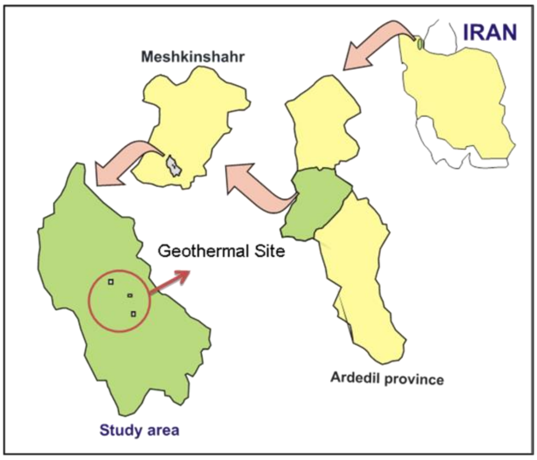

Figure 7. Location of Sabalan field in Iran

First stage of exploration program in Meshkin-shar began in 1998 in conjunction with New Zealand consulting engineer (KML).The program completed in 1999 indicating three locations for deep exploration drillings as shown in Figure 8.

Drilling operation of the first geothermal exploration well commenced By NIDC in November 2002 and supervised By SKM. SKM also conducted the evaluation of the data gathered during drilling and flow testing, geothermal reservoir assessment and response simulation, location of new wells and feasibility study of a geothermal power plant for producing electricity.

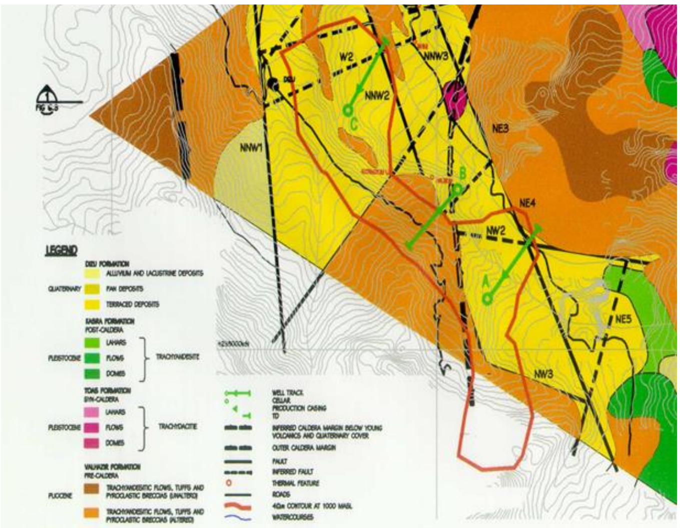

Figure 8. Three locations for deep exploration drillings

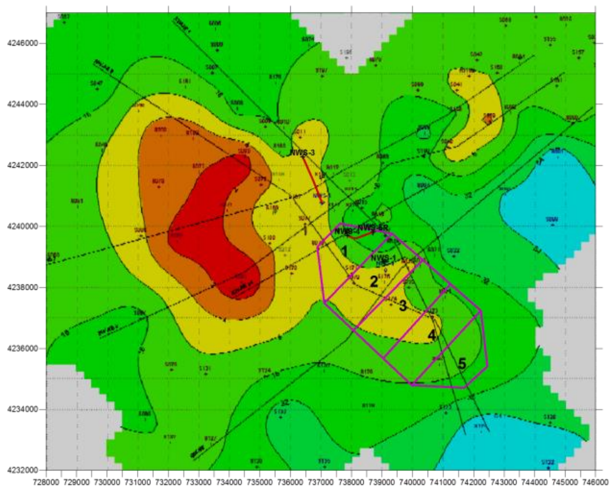

Figure 9. Areas Used for Stored Heat Calculations

In Figure 9 Area 1 is associated with NWS-4 (Pad B) and Area 2 with NWS-1 (Pad A). Areas 3, 4 and 5 are assumed to have progressively higher temperatures towards the postulated source of the outflow..

The Monte Carlo analysis was undertaken for the area as a whole to give the probability distribution for the whole area. Results from the individual areas were used to guide the selection of average properties for the whole area. Three layers were also used for the whole area analysis.

The areas and mean values of estimated power potential for each of the five individual areas are summarized in Table 1.

Table 1. Summary of Stored Heat Values for Each Block

	Block 1	Block 2	Block 3	Block 4	Block 5	Total
Area (km^2)	**3.2**	**4.2**	**4.2**	**4.3**	**3.1**	**19**
Mean MWe	**23**	**41**	**45**	**52**	**45**	**206**

The calculated parameters indicate that the potential capacity of the NW Sabalan resource has a mean value of 209 MWe, with a 90% probability of being greater than 125 MWe and a 50% probability of being greater than 205 MWe. The average calculated energy density for the whole area is 11 MW/km^2.

After completion of the First Stage of Exploration SKM proposed the following steps for Second stage.

1. An ongoing delineation drilling program be undertaken at Pads D and E. The results from the delineation program would determine the most suitable size for the stage of development.

This first well in second stage (NWS5) was drilled directionally to North-East to a Td of 1,900m

According the MT results the well NWS6 was drilled directionally to South-East to a Td is 2374m.

Table 2 show details of all of wells drilled in the first and second stage and Figure 10 shows their direction and locations. Table 6 shows wells drilled for electrical, direct and combined use of geothermal resources from January 1, 2010 to December 31, 2014 (excluding heat pump). Table 8 shows total investments in geothermal in (2014) US$

Table 2. Details of all of wells drilled in first and second stage

total	NWS 11	NWS 10	NWS 9	NWS 8	NWS 7	NWS 6	NWS 5	NWS 4	NWS 3	NWS 2	NWS 1	Well Name
4	C	D	E	E	D	D	B	B	C	A	A	Site
26459	2813	2300	2700	2413	2705	2371	1901	2255	3166	638	3197	Depth (m)
	directional	directional production	directional production	directional	directional production	directional production	directional production	directional production	directional	directional Injection	vertical production	Type
263	-	40	38	-	41	40	50	26	-	-	28	Flow rate (lit/s)
72	-	11	10	-	11	11	14	7	-	-	8	Thermal Power (MWt)
31/4	-	5.4	4	-	5.5	5.4	6	3	-	-	2	Electrical Power (MWe)

By plotting the well temperature profiles together on Figure 11 it is possible to make a number of observations regarding the nature of the geothermal resource based on changes in temperature with depth as following:

1-The temperatures are all below the BPD curve, indicating that the reservoir in this area of the field does not contain a two-phase mixture of steam and water.

2-Temperatures behind the casing of NWS-1 at an elevation of about 1,900 masl are close to BPD conditions, indicating possible proximity to two-phase fluid.

3-From +1,700 masl to between – 500 masl a slight temperature inversion is evident.

4-Below +200 masl in NWS-1 and +600 masl in NWS-3 temperatures increase with depth.

5-The hottest temperature has been measured in 240^{o}C

As you can see in Table 2 the production wells could product 31.5 MW electricity and 72 MW thermal power. The tender of a 5 MWe portable power plant was issued and 6 EPC contractors bought it and we hope after finalization of the tender process we can start first demonstration power plants. We are going to simultaneously construction of first power plant and will prepare necessary documents for developing field by private financers.

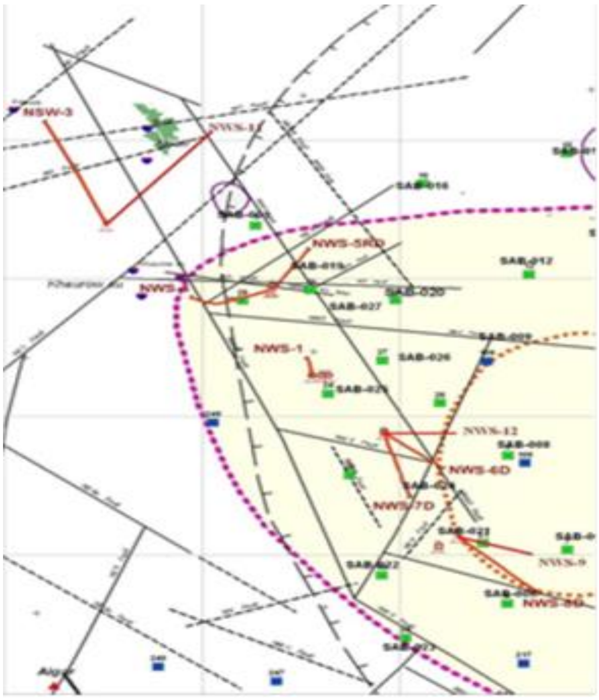

Figure 10. Location and direction of all of wells drilled in first and second stage.

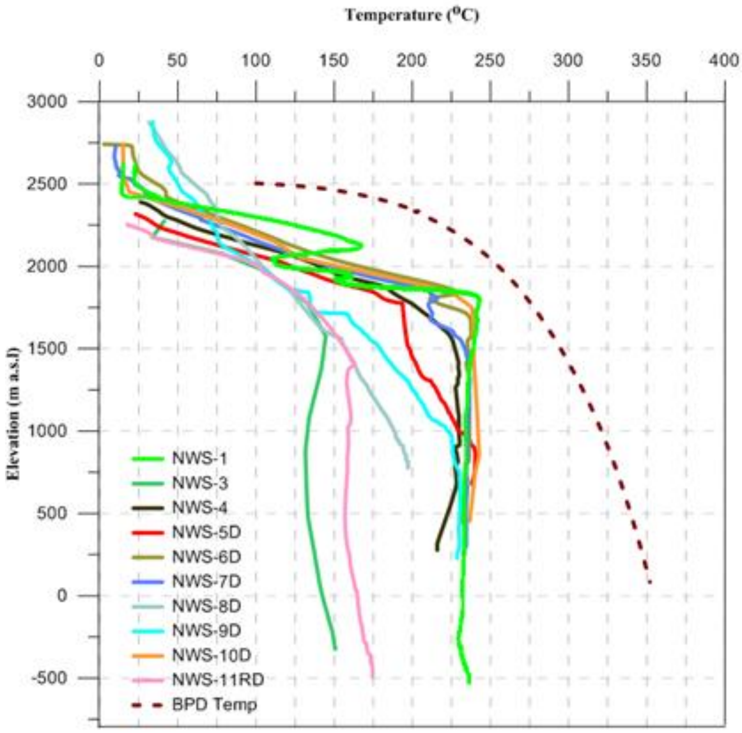

Figure 11. The well temperature profiles

4.0 DIRECT USE APPLICATIONS

According to Table 2, there are 72 MWt capacity of direct use application near the power plant. Therefore a contract was signed between SUNA and an Iranian company (ATEK CO.) for a feasibility study of direct utilization. According to the ATEK report it is possible to use hot water for space heating, greenhouse heating, aquaculture pound heating, tourism utilization and research center for direct use utilization. Figure 12 shows the location for each kind of utilization base of GIS study. Figure 13 shows a flow diagram of Thermodynamic cycle which is optimized for different type of utilizations. After installation of the power plant and required equipment for scaling inhibition then we have continues hot brine. We are going to ask private sector to investigate for development direct use applications. Table 3 gives bathing and swimming utilization (including balneology)

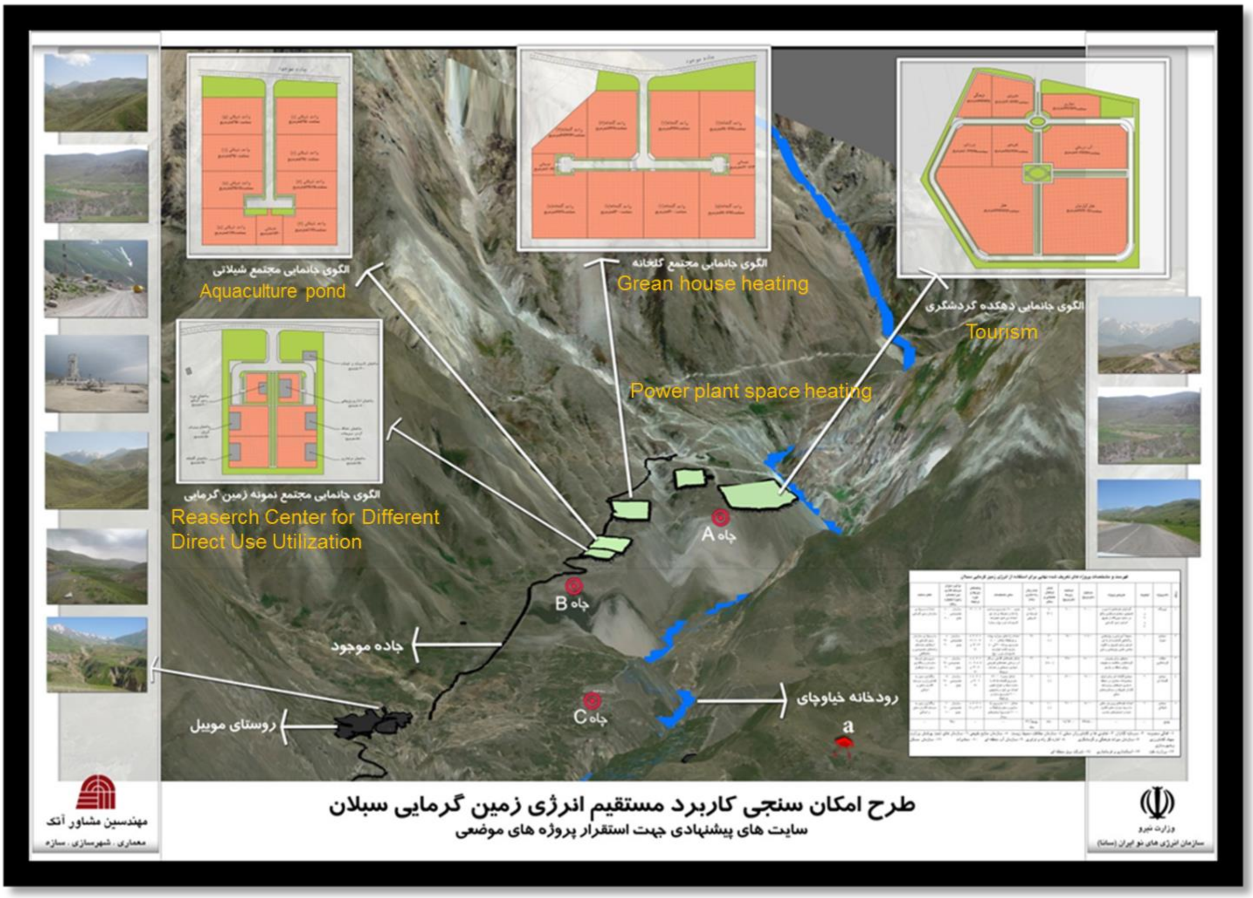

Figure 12. The location located for each kind of direct utilization based of GIS study

5.0 HEAT PUMP APPLICATIONS

Activities of heat pump started 2005 by changing air to air heat pump to water to air heat pump. In this study, we got 30 percent of the saving energy. After this first step for demonstration of geothermal heat pump to governmental decision maker, they asked to install 4 standard heat pumps in 4 different climates. Therefore we bought 4 FHP heat pump with 1.5 TR capacity and installed in following locations

Rasht city as representative for wet and normal climate

Bandar Abbas city as representative of wet and tropical climate

Ahvaz as representative for dry and tropical climate

Taleghan as representative for cold climate

After installation of these heat pumps with ground heat exchangers we installed data loggers on them. According to the data gathered we calculate 60 percent of energy saving compared to air to air heat pumps. One of the problems for developing the geothermal heat pumps was sanctions of Iran because the price of heat pump increased by 2 times. Now we have a local company which could produce this equipment. Another problem was companies which could install ground heat exchangers in large scale and for solving this problem we need to develop a market of heat pumps. If the companies have good contracts then they can buy drilling rigs and other requirements for installations. There are big markets in government building special in oil and gas industry, power industry and municipality. For developing heat pumps in private buildings we need subside for geothermal heat pumps. SUNA is studying it and trying to get a budget for them. Figure 14 shows distribution of geothermal heat pumps in Iran. Figure 15 shows annual and total installed capacity of geothermal heat pumps in Iran. Table 4 give geothermal (ground source) heat pumps as of 31 December 2014.

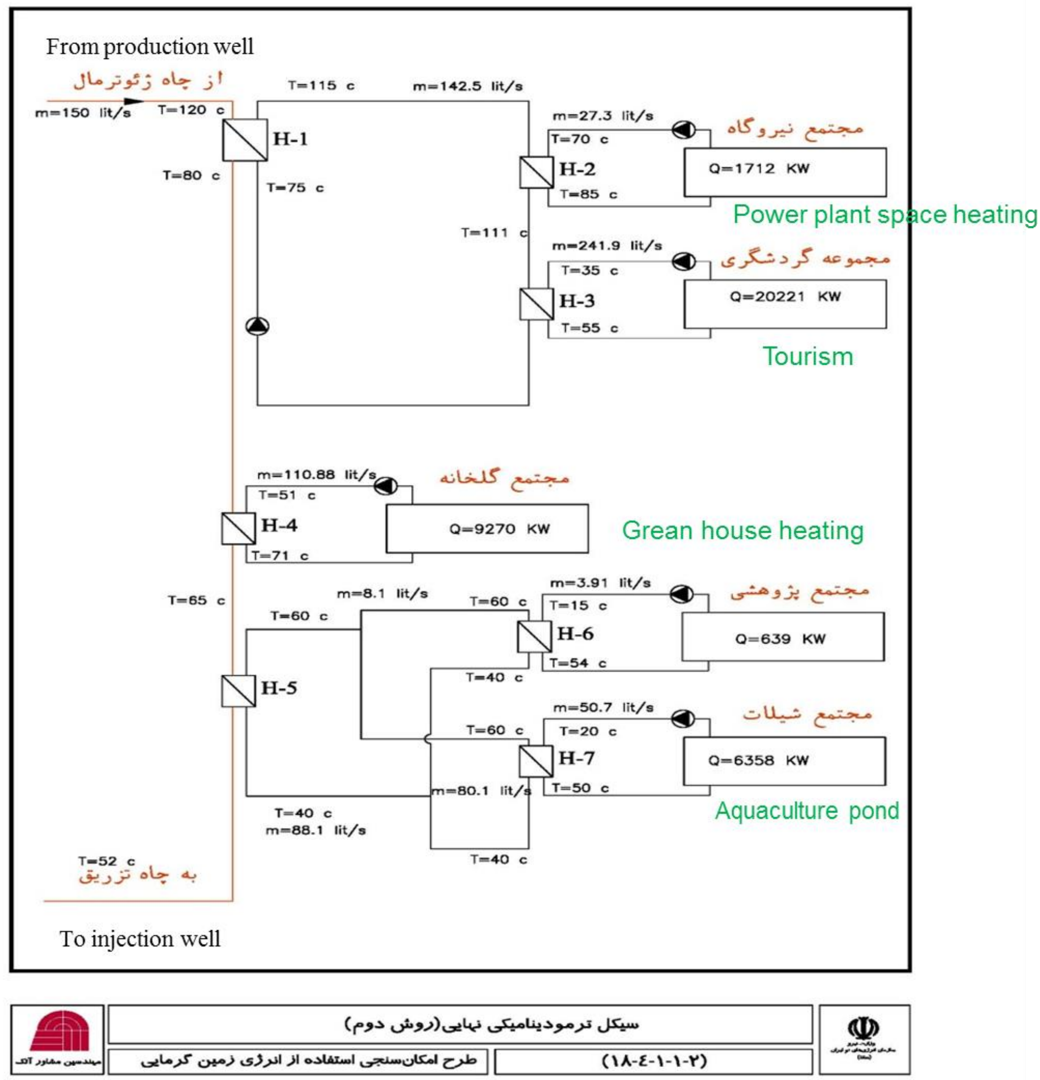

Figure 13. Flow diagram of Thermodynamic cycle optimized for different type of direct utilizations.

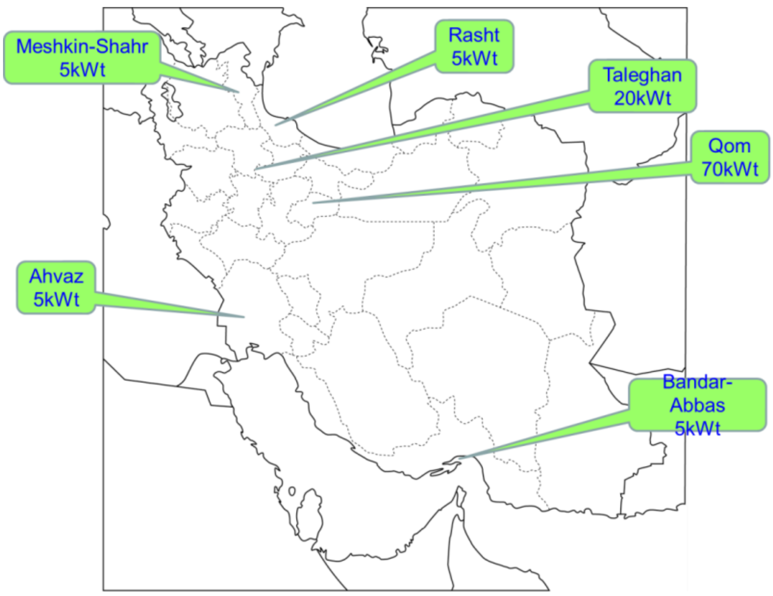

Figure 14. Distribution of geothermal heat pumps in Iran.

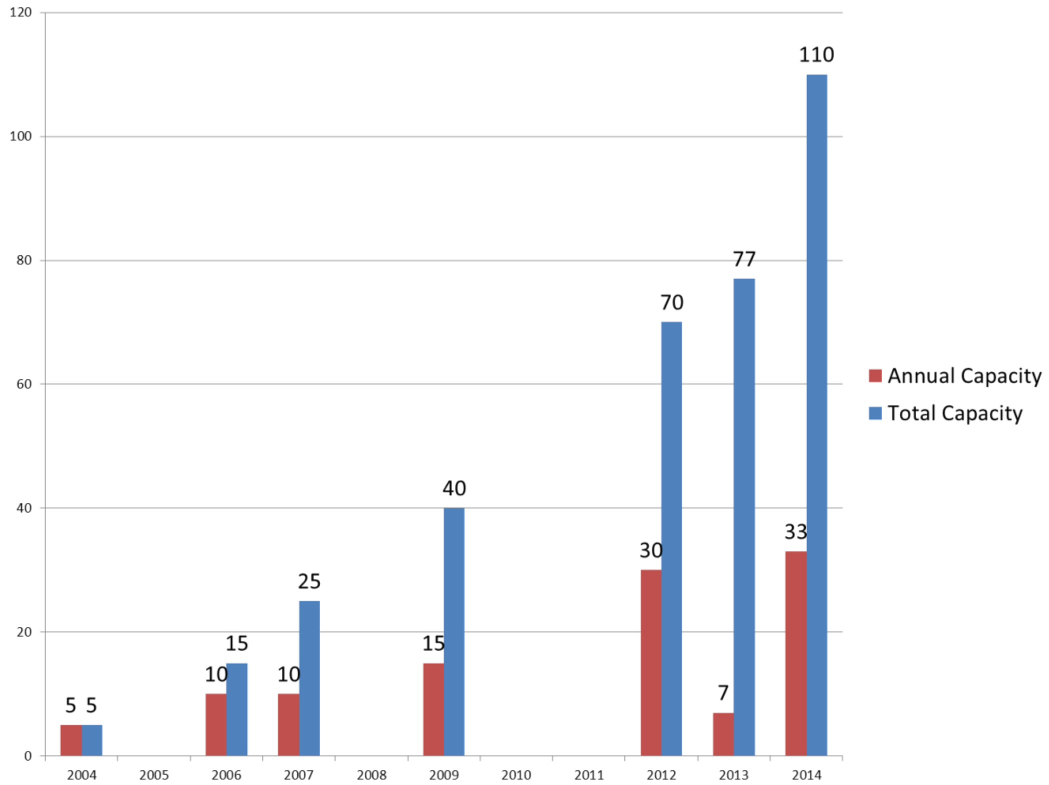

Figure 15. Annual and total installed capacity of geothermal heat pumps in Iran

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STANDARD TABLES

TABLE 3 UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DEC. 2014 (other than heat pumps)

1) B = Bathing and swimming (including balneology)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184

or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319

or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171

		Maximum Utilization			Capacity[3)]	Annual Utilization		
Locality	Type[1)]	Flow Rate	Temperature (°C)			Ave. Flow	Outlet	Capacity
		(kg/s)	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Ramsar(4)	B	2	42	32	0.12552	2	2.638	1
Khalil abad	B	3	33	23	0.12552	3	3.957	1
Ramsar(1)	B	3	41	31	0.25104	3	3.957	1

Ramsar(2)	B	6	48	38	3.57732	6	7.914	1
Mashkhal	B	85.5	28	18	0.217568	85.5	112.7745	1
Luyeh	B	5.2	32	22	0.23012	5.2	6.8588	1
Bashkandy	B	5.5	32	22	0.04184	5.5	7.2545	1
Shah abad	B	1	37	27	0.04184	1	1.319	1
Zavieh	B	1	37	27	0.225936	1	1.319	1
Siahcheshmeh	B	5.4	58	48	0.16736	5.4	7.1226	1
Shely	B	4	31	21	0.08368	4	5.276	1
Ghare aghaj(1)	B	2	50	40	0.050208	2	2.638	1
Khan	B	1.2	41	31	0.23012	1.2	1.5828	1
Derik	B	5.5	35.5	25.5	0.2092	5.5	7.2545	1
Istisu	B	5	38.5	28.5	0.2092	5	6.595	1
Haft abad	B	5	34	24	0.16736	5	6.595	1
Hamam	B	4	38	28	0.37656	4	5.276	1
Ghare aghaj(2)	B	9	51	41	0	9	11.871	1
Mineshgar	B		54	44	0.2092	0	0	1
Shahindezh	B	5	28	18	0.25104	5	6.595	1
Ahmad abad	B	6	35	25	0.58576	6	7.914	1
Gheinarjeh	B	14	35	25	0.12552	14	18.466	1
Dar band	B	3	37	27	0.08368	3	3.957	1
Marand	B	2	25	15	0.2092	2	2.638	1
Hamam	B	5	55	45	1.6736	5	6.595	1
Anish ahmad	B	40	60	50	0.242672	40	52.76	1
Ghaleh kandy	B	5.8	45	35	0.259408	5.8	7.6502	1
Shalghon	B	6.2	32	22	0.08368	6.2	8.1778	1
Abres	B	2	29	19	0.2092	2	2.638	1
Lighvan	B	5	31	21	0.6276	5	6.595	1
Bostan abad	B	15	41	31	0.217568	15	19.785	1
Alah hagh	B	5.2	39	29	0.2092	5.2	6.8588	1
Asbforoshan	B	5	42	32	0.08368	5	6.595	1
Ardahal	B	2	35	25	0.025104	2	2.638	1
Jaldehbekhan	B	0.6	36	26	0.02092	0.6	0.7914	1
Termeh	B	0.5	28	18	0.066944	0.5	0.6595	1
Shekar dareh	B	1.6	36	26	0.08368	1.6	2.1104	1
Boshlu	B	2	54	44	0	2	2.638	1
Tir	B		67	57	0.66944	0	0	1
Gheinarjeh	B	16	85	75	0.117152	16	21.104	1
Monil	B	2.8	46	36	0.3138	2.8	3.6932	1
Ilandu	B	7.5	39	29	0.092048	7.5	9.8925	1
Shahbil	B	2.2	51	41	1.54808	2.2	2.9018	1
Ghotor sui	B	37	39.5	29.5	0.08368	37	48.803	1
Haft cheshmeh	B	2	35	25	0.33472	2	2.638	1
Sardabeh	B	8	37	27	0.50208	8	10.552	1
Vila dare	B	12	27	17	0.108784	12	15.828	1
Ilsuyeh	B	2.6	47	37	0.133888	2.6	3.4294	1
Panj khaharan	B	3.2	45	35	0.100416	3.2	4.2208	1
Jeneral	B	2.4	45	35	0.37656	2.4	3.1656	1
Sari suyeh	B	9	47	37	0.133888	9	11.871	1
Ghare suyeh	B	3.2	45	35	3.3472	3.2	4.2208	1
Gharmish goli	B	80	49	39	0.075312	80	105.52	1
Abgarm-e-paein	B	1.8	41	31	0.75312	1.8	2.3742	1
Ilanjagh	B	18	56	46	0.100416	18	23.742	1
Sakcelu	B	2.4	43	33	0.066944	2.4	3.1656	1
Ghare shalan	B	1.6	46	36	0.33472	1.6	2.1104	1

Khalkhal	B	8	66	56	0.16736	8	10.552	1
Shorab	B	4	27	17	0.02092	4	5.276	1
Tashvir	B	0.5	30	20	0.25104	0.5	0.6595	1
Logahi	B	6	36	26	0.06276	6	7.914	1
Abas abad	B	1.5	33	23	0.33472	1.5	1.9785	1
Ghotor sui	B	8	28	18	0.12552	8	10.552	1
Hadighi	B	3	54	44	0.06276	3	3.957	1
Mehrabad	B	1.5	25	15	0.02092	1.5	1.9785	1
Alishar	B	0.5	25	15	0.25104	0.5	0.6595	1
Samarghand	B	6	26	16	0.08368	6	7.914	1
Sadat mahale	B	2	40	30	0.29288	2	2.638	1
Yaleh gonbad	B	7	45	35	1.8828	7	9.233	1
Larich(1)	B	45	47	37	0.33472	45	59.355	1
Estrabako(1)	B	8	29.5	19.5	0.08368	8	10.552	1
Estrabako(2)	B	2	32	22	0.02092	2	2.638	1
Estrabako(3)	B	0.5	31	21	0.02092	0.5	0.6595	1
Estrabako(4)	B	0.5	31.5	21.5	1.6736	0.5	0.6595	1
Larijan	B	40	65	55	0.02092	40	52.76	1
Zaghcheshme	B	0.5	28	18	0.25104	0.5	0.6595	1
Hormoz	B	6	32	22	0.06276	6	7.914	1
Pashank	B	1.5	29	19	0.04184	1.5	1.9785	1
Cheshmeh(1)	B	1	28	18	0.18828	1	1.319	1
Cheshmeh(2)	B	4.5	29	19	0.08368	4.5	5.9355	1
Lavich(2)	B	2	45	35	0.08368	2	2.638	1
Joshan	B	2	49	39	0	2	2.638	1
Tanor	B		35	25	0.12552	0	0	1
Dalir	B	3	35	25	0.29288	3	3.957	1
Sadat mahaleh	B	7	40	30	0.2092	7	9.233	1
Abgarm kesh	B	5	34	24	0.2092	5	6.595	1
Ramsar(3)	B	5	37	27	0.12552	5	6.595	1
Tehran-qom	B	3	29	19	0.02092	3	3.957	1
Cheshme salok	B	0.5	29	19	0.33472	0.5	0.6595	1
Nimor	B	8	41	31	0.4184	8	10.552	1
Mahalat(1)	B	10	47	37	1.2552	10	13.19	1
Mahalat(2)	B	30	45	35	0.25104	30	39.57	1
Mahalat(3)	B	6	32	22	0	6	7.914	1
Mahalat(4)	B		48	38	0.12552	0	0	1
Garu	B	3	27	17	0.08368	3	3.957	1
Shiran bishe	B	2	26	16	0.33472	2	2.638	1
Keshvar	B	8	32	22	0.6276	8	10.552	1
Dehluran	B	15	42	32	0.29288	15	19.785	1
Ghir	B	7	32	22	0.16736	7	9.233	1
Varton	B	4	41	31	0.12552	4	5.276	1
Morad	B	3	36	26	0.08368	3	3.957	1
Khor(1)	B	2	43	33	0.08368	2	2.638	1
Khor(2)	B	2	43	33	0.08368	2	2.638	1
Khor(4)	B	2	40	30	0.08368	2	2.638	1
Khor(5)	B	2	38	28	0.92048	2	2.638	1
Behbahan	B	22	29	19	0.04184	22	29.018	1
Istgah-e-abgarm	B	1	26	16	0.08368	1	1.319	1
Abgarm-e-semnan	B	2	35	25	0.4184	2	2.638	1
Shorabad	B	10	25	15	0.25104	10	13.19	1
Garu	B	6	38	28	0.4184	6	7.914	1
Abmorad	B	10	39	29	0.33472	10	13.19	1

Gholenj	B	8	35	25	1.6736	8	10.552	1
Haji abad	B	40	37	27	1.046	40	52.76	1
Fotuhie	B	25	39	29	2.7196	25	32.975	1
Todulieh	B	65	55	45	0.6276	65	85.735	1
Gharb-e-todulieh	B	15	54	44	0.29288	15	19.785	1
Charak	B	7	42	32	0.29288	7	9.233	1
Ask	B	7	31	21	0.08368	7	9.233	1
Molaeiji	B	2	38	28	0.02092	2	2.638	1
Sayehkhosh	B	0.5	33	23	0.12552	0.5	0.6595	1
Badon	B	3	30	20	0.08368	3	3.957	1
Chah ahmad	B	2	35	25	1.046	2	2.638	1
Khorgo(3)	B	25	44	34	0.29288	25	32.975	1
Bari	B	7	39	29	1.6736	7	9.233	1
Sorkhan	B	40	49	39	1.6736	40	52.76	1
Nian	B	40	39	29	0.29288	40	52.76	1
Khorgo(1)	B	7	32	22	0.58576	7	9.233	1
Khorgo(2)	B	14	36	26	0.08368	14	18.466	1
Bibihakimeh(1)	B	2	33	23	0.08368	2	2.638	1
Bibihakimeh(2)	B	2	35	25	1.6736	2	2.638	1
Norabad	B	40	31	21	4.184	40	52.76	1
Maharlu	B	100	26	16	1.17152	100	131.9	1
Aviz	B	28	28	18	1.00416	28	36.932	1
Khanik(1)	B	24	26	16	1.00416	24	31.656	1
Khanik(2)	B	24	26	16	1.4644	24	31.656	1
Jegriz	B	35	50	40	0.50208	35	46.165	1
Firoz abad	B	12	25	15	3.43088	12	15.828	1
Ab boti	B	82	33	23	0.4184	82	108.158	1
Kherg	B	10	40	30	0.50208	10	13.19	1
Ganobeh	B	12	25	15	0.25104	12	15.828	1
Mianlu	B	6	29	19	0.12552	6	7.914	1
Ghalat	B	3	33	23	0.025104	3	3.957	1
Sharif abad	B	0.6	25	15	0.08368	0.6	0.7914	1
Shomal-e-sharif abad(1)	B	2	25	15	0.08368	2	2.638	1
Shomal-e-sharif abad(2)	B	2	25	15	0.2092	2	2.638	1
Ashke rostam	B	5	60	50	0.8368	5	6.595	1
Ziaratgah	B	20	38	28	1.50624	20	26.38	1
Dige rostam	B	36	75	65	0.278236	36	47.484	1
Dehu	B	6.65	26	16	1.2552	6.65	8.77135	1
Robat bozorg	B	30	31	21	0.75312	30	39.57	1
Dalik	B	18	36	26	0.50208	18	23.742	1
Borazjan	B	12	33	23	0.50208	12	15.828	1
Aharb	B	12	44	34	0.50208	12	15.828	1
Mir ahmad	B	12	35	25	0.2092	12	15.828	1
Ghocharak	B	5	32	22	0.4184	5	6.595	1
Niko	B	10	32	22	0.37656	10	13.19	1
Dah sheikh	B	9	39	29	0.02092	9	11.871	1
Dah reeis	B	0.5	35	25	0.58576	0.5	0.6595	1
Soltan hasan shah	B	14	41	31	0.221752	14	18.466	1
Lale zar	B	5.3	40.5	30.5	0.02092	5.3	6.9907	1
Gishky	B	0.5	39	29	0.217568	0.5	0.6595	1
Abraq(1)	B	5.2	58	48	1.4644	5.2	6.8588	1
Abraq(2)	B	35	35	25	0.029288	35	46.165	1
Maskon	B	0.7	40	30	0.16736	0.7	0.9233	1
Abgarm seied	B	4	34	24	1.4644	4	5.276	1

Sarze	B	35	33	23	0.02092	35	46.165	1
Ravar	B	0.5	34	24	0.33472	0.5	0.6595	1
Pozebagh	B	8	33	23	0.04184	8	10.552	1
Tong	B	1	37	27	0.58576	1	1.319	1
Makran	B	14	34	24	0.25104	14	18.466	1
Tasht	B	6	33	23	0.33472	6	7.914	1
Jamshid	B	8	44	34	0.29288	8	10.552	1
Espidezh	B	7	33	23	0.02092	7	9.233	1
Paikohsorkh	B	0.5	28	18	0.33472	0.5	0.6595	1
Bazman(1)	B	8	35.5	25.5	0.58576	8	10.552	1
Bazman(2)	B	14	35.5	25.5	0.008368	14	18.466	1
Katukan	B	0.2	29	19	0.6276	0.2	0.2638	1
Kulko	B	15	25	15	0.37656	15	19.785	1
Doshing	B	9	25	15	0.50208	9	11.871	1
Shargh-e-taftan	B	12	35	25	0.04184	12	15.828	1
Barabak	B	1	25	15	0.08368	1	1.319	1
Garmok	B	2	28	18	0.29288	2	2.638	1
Cheshme ayoub	B	7	38	28	0.4184	7	9.233	1
Taghku	B	10	29	19	0.25104	10	13.19	1
Ghochan	B	6	26	16	0.217568	6	7.914	1
Alamkoh	B	5.2	33	23	0.50208	5.2	6.8588	1
Ghale no	B	12	34	24		12	15.828	1
Summation		1943.25	6981	5121	81.30558	1943.25	2563.147	186

TABLE 4.GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2014

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

2) Report type of installation as follows: V = vertical ground coupled
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

Locality	Ground or Water Temp. (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]
Rasht	25	5	1	h-v
Meshkin-Shahr	20	5	1	h
Taleghan	22	20	4	v-h
Ahvaz	26	5	1	Slinky
Bandar Abbas	26	5	1	Slinky
Qom (Jemezghan)	19	10	3	v
Qom(ghanavat)	25	35	1	v
Qom(salarieh)	24	5	1	Slinky
mashad	22	21	1	o
TOTAL		191	11	

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2010 TO DECEMBER 31, 2014 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)	7	1		1	26.5
Production	>150° C	7	1			15.24
	150-100° C				1	3160
	<100° C					
Injection	(all)	2				3441
Total		9	1		1	26.5

Table 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES(Restricted to personnel with University degrees)

(1)Government
(2)Public Utilities
(3)Universities
(4)Paid Foreign Consultants
(5)Contributed Through Foreign Aid Programs
(6)Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	15		18	15		51
2011	18		18	15		52
2012	18		18	15		54
2013	17		18			28
2014	17		14			14
Total	85	0	86	45	0	199

Table 8.TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	1					100
2000-2004	13.36					100
2005-2009	30	20.7				100
2010-2014	5.88					100