Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Geothermal Energy in Iran

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Keywords: geothermal, status, Iran, Meshkinshahr, heat pump

ABSTRACT

Activities in the field of geothermal energy in Iran are focused on scientific and research aspects, and 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), private sector is expected to have a share of at least 500 MW 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. 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 MW power plant for 5 km^2 area was proved. Extention of reservoir has been predicted 20 km^2 and 250 MW 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, temperature increases so high that stones and soils are melted. If underground flowing water passes in close vicinity, it becomes hot. The Geothermal resources is not 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 Island, 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 10715 MW(Bertani,2010).

Geothermal energy is fuelled by a resource that is sustainable in economic, social and environmental terms .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 POWER GENERATION

By 2019, Iran had roughly 1419 power plant units By the end of 2019, Iran had a total installed electricity generation capacity of 80,605 MW, which had been increased from 78794 MW in 2018.It is planned to add more than 5,000 MW of generation capacity annually to the power grid, which will be total power generation capacity to 122,000 MW by 2022[5][6]. The natural gas was the major fuel used to generate. Table 1 show the present and planned production of electricity.

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, North West of 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 NW Iran. Fig 1 shows 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 Fig 2)

Table 1. Present and planned production of electricity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity	Gross Prod.	Capacity	Gross Prod.	Capacity	Gross Prod.	Capacity	Gross Prod.	Capacity	Gross Prod.	Capacity	Gross Prod.
	MWe	GWh/yr	MWe	GWh/yr	MWe	GWh/yr	MWe	GWh/yr	MWe	GWh/yr	MWe	GWh/yr
In operation in December 2019	0	0	66960	286838	12026	15983	1020	7485.277	600	1167.849	80605	311474.1
Under construction in December 2019	5	35	5000	21418	1000	1329	0	0	95	184	7100	22967.4
Funds committed, but not yet under construction in December 2019												
Estimated total projected use by 2020	5	35	71960	308256.6	13026	17312	1020	7485.277	696	1352.624	87705	334441.5

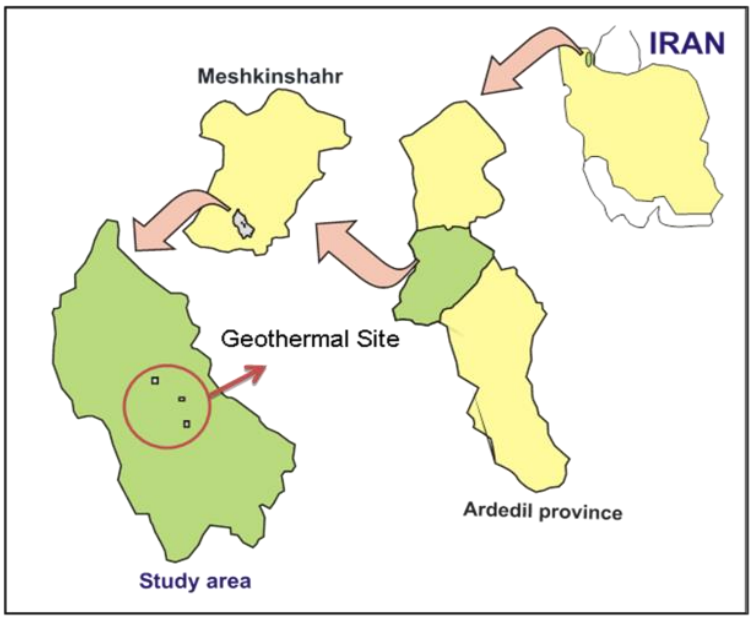

Fig 1. Location of Sabalan field in Iran

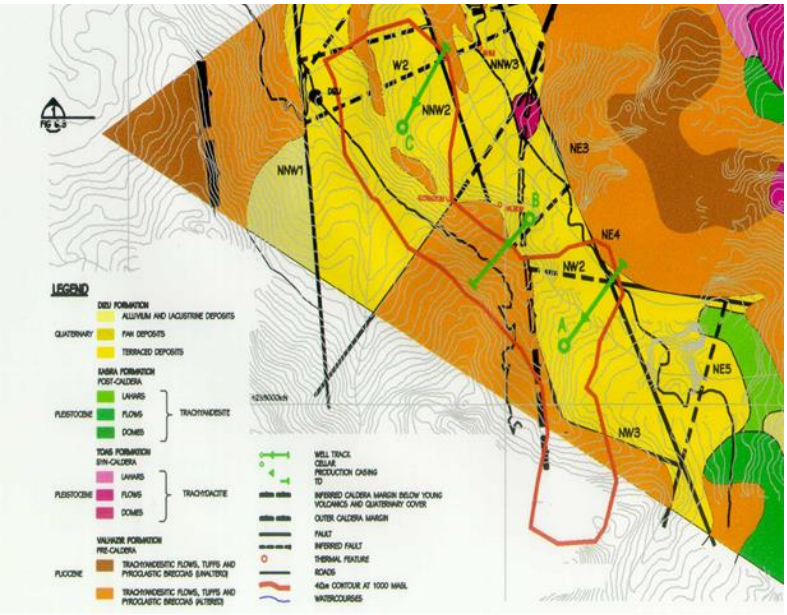

Figure. 2 Three locations for deep exploration drillings

Drilling operation of the first geothermal exploration well commenced By NIDC in November 2002 and supervised By SKM.The SKM also was 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 producing electricity

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.

Table 2 show detail of all of wells drilled in first and second stage and fig 9 shows their direction and locations. Table 5 shows wells drilled for electrical, direct and combined use of geothermal resources from January 1, 2015 to December 31, 2019 (excluding heat pump).table 9 shows total investments in geothermal in (2015) US$

Table 2 show detail 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)

According to Table 2 the production wells could product 31.5 MW electricity and 72 MW thermal power.

Table 3. *W*ells drilled for electrical, direct and combined use of geothermal resources from january 1, 2015 to december 31, 2019 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)	5	2			10
Production	>150º C	7	40			19.24
	150-100º C					
	<100º C					
Injection	(all)	1				.6
Total		13	42			29.84

Table 4 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 5.total investments in geothermal in (2019) 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
2015-2020				22		100

3-- DIRECT USE APPLICATIONS

According table 6 there are 81.74 MW capacity of direct use application from springs . all of this applications is balneology and resort.

Table 6 utilization of geothermal energy for direct heat as of 31 dec. 2019 (other than heat pumps)

[1] I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

[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
Ayghar gheinarjeh Meshkinshahr	B	1.5	82	72	0.06276	1.5	1.9785	1

Dorna Meshkinshahr	B	1.5	37	30	0.043932	1.5	1.38495	1
Ghainar savalan Meshkinshahr	B	1.5	60	50	0.06276	1.5	1.9785	1
Akhar Bakhar Meshkinshahr	B	1.5	46	36	0.06276	1.5	1.9785	1
Negin DoDo Meshkinshahr	B	1.5	46	36	0.06276	1.5	1.9785	1
Yele souei Meshkinshahr	B	1.5	45.5	35	0.065898	1.5	2.077425	1
Valezir Meshkinshahr	B	1.5	36	28	0.050208	1.5	1.5828	1
Shafa Meshshahr	B	1.5	29	25	0.025104	1.5	0.7914	1
Sumation		1960.25			81.741762	1960.25	2576.898	

3-1 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 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 this heat pumps with ground heat exchangers we install data loggers on them. According to data gathered we calculate 60 percent of saving energy compered 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 product this equipment. Another problem was companies which could install ground heat exchangers in large scale and for solving this problem we need to develop market of heat pump. If the companies have good contracts then bought drilling rigs and other requirements for installations. There are big market in government building special in oil and gas industry, power industry and MUNICIPALITY. For developing heat pumps in private building we need subside for geothermal heat pumps. Suna is studding on it and try to get budget for them. Fig 3 shows distribution of géothermal heat pumps in Iran .Fig 4 shows annual and total installed capacity of geothermal heat pumps in Iran. Table 7 give geothermal (ground source) heat pumps as of 31 August 2019

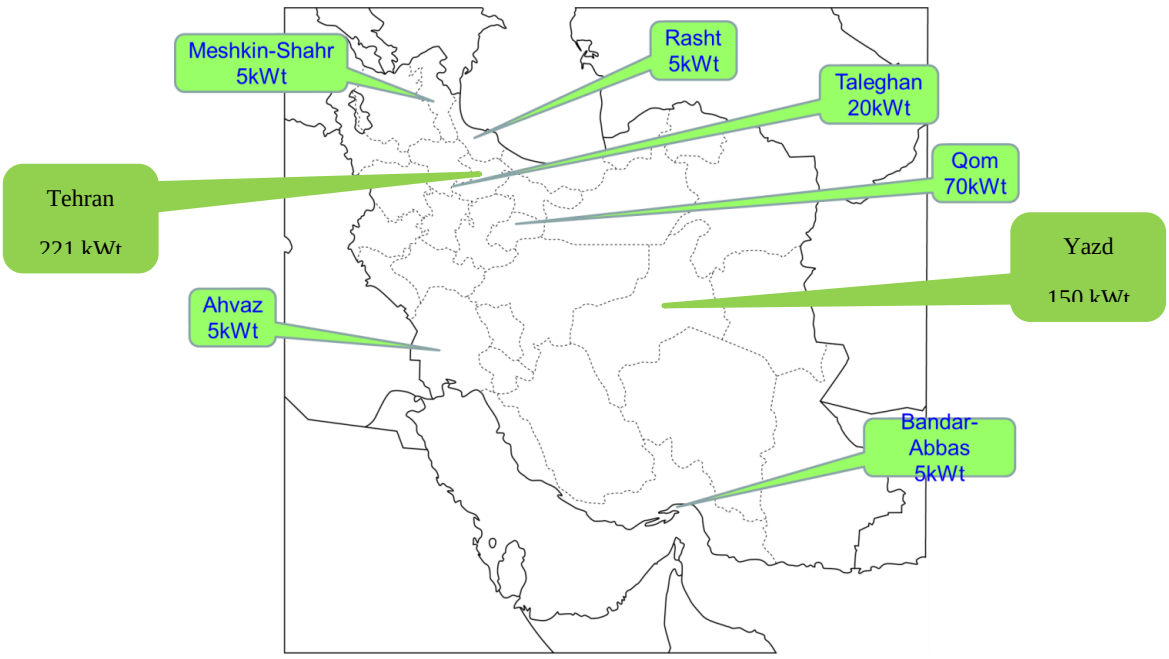

Figure 3 Distribution of geothermal heat pumps in Iran

Porkhial

Table 7. Geothermal (ground-source) heat pumps as of 31 december 2019

Report type of installation as follows:

[2)]

W = water source (well or lake water) V = vertical ground coupled

O = others (please describe) H = horizontal ground coupled

Locality	Ground or Water Temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	Thermal Energy Used[5)] (TJ/yr)	Cooling Energy[6] (TJ/yr)
Rasht	25	5	1	h-v	0.0648	0.0648
Meshkin-Shahr	20	5	1	h	0.10368	0.02592
Taleghan	22	20	4	v-h	0.2592	0.2592
Ahvaz	26	5	1	Slinky	0.01296	0.14256
Bandar Abbas	26	5	1	Slinky	0.01296	0.14256
Qom (Jemezghan)	19	10	3	v	0.1296	0.1296
Qom(ghanavat)	25	35	1	v	0.4536	0.4536
Qom(salarieh)	24	5	1	Slinky	0.0648	0.0648
mashad	22	21	1	o	0.27216	0.27216
Tehran Vardavard	18	157.5	9	v	2.0412	2.0412
Tehran-municipality -22	20	21	1	v	0.27216	0.27216
Tehran-municipality -1	20	15	1	v	0.1944	0.1944
Tehran-municipality -11	20	10	1	v	0.1296	0.1296
Tehran -university	22	17.5	1	v	0.2268	0.2268
Yazd-university	22	150	5	v-h-slinky	1.944	1.944
TOTAL		482	32		6.36336	6.18192

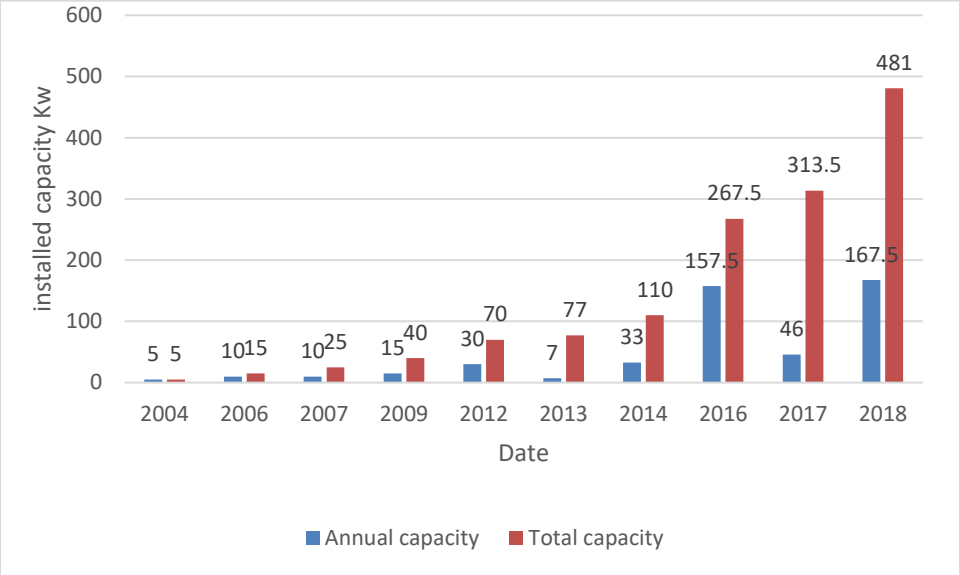

Figure 4 annual and total installed capacity of geothermal heat pumps in Iran

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