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FEASIBILITY STUDY OF DIRECT APPLICATION OF TWO DEEP AND DRY GEOTHERMAL WELLS FOR HEATING THE BUILDINGS OF MOEIL VILLAGE

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دراسة جدوى للتطبيق المباشر لعائلتي ديب وجيورمال الأرض الجافة للتسخين في مباني قرية مويل

ملخص

التطبيق المباشر للطاقة الحرارية الأرضية يعني أن الطاقة الحرارية الأرضية لم تعد تتحول إلى طاقة كهربائية . في عملية الاستخدام المباشر ، يتم استخدام السوائل الحرارية الأرضية المنخفضة إلى المتوسطة (١٥٠–٥٠ درجة مئوية). يمكن أيضًا استخراج سوائل هذه الخزانات عن طريق حفر الآبار. في الوقت الحالي ، تمت دراسة بئرين من محطة سبالان لتوليد الطاقة في مشجن شهر ، وهما NWS-3 و NWS-11RD ، من حيث الإمداد الحراري لقرية مويل. أشارت نتائج حفر البئرين إلى أن درجة حرارة الخرج للآبار NWS-3 و NWS-11RD كانت ٤٠ و ٤٢ درجة مئوية على التوالي ، وكان ضغط الخرج للآبار NWS-3 و NWS-11RD 3 atm ومعدل التدفق لآبارين NWS -3 و NWS-11RD كان ١.٢ و ٥ مضاءة / ثانية على التوالي. لتوفير التدفئة لمباني قرية مويل ، لم يكن من الممكن استغلال الآبار مباشرة مع هذا السائل. لهذا الغرض ، تم البحث في أربع طرق باستخدام مضخة الحرارة الحرارية الأرضية ومياه النهر ، والتي كانت أفضل طريقة لزيادة معدل تدفق NWS11 إلى ١٠ مرات باستخدام المضخة الحرارية ، مما أدى إلى تسخين ٣٠٠ مبنى بسعة حرارية تبلغ ٧ كيلو وات أو ٢٤٠٠٠ وحدة حرارية بريطانية / ساعة. بالطبع ، إذا تم تقليل السعة الحرارية للمباني بسبب انخفاض مساحة البنية التحتية أو استخدام عوازل البناء ، فسيتم زيادة عدد المباني التي تم تسخينها بها.

Abstract

Direct application of geothermal energy means that geothermal energy is no longer converted to electrical energy. In the direct application, Fluids are used at low to medium temperatures (150-50 ° C). With water drilling equipment, the fluids of these reservoirs can also be exploited. At present study, two wells of the Sabalan Power Plant of Meshginshahr, namely NWS-3 and NWS-11RD, were studied in terms of heat supply of the Moeil Village. The drilling results of the two wells indicated that the output temperature for NWS-3 and NWS-11RD wells was 40 and 42°C respectively, the output pressure for NWS-3 and NWS-11RD wells was 3 atm and the flow rate for two NWS wells-3 and NWS-11RD was 1.2 and 5 lit/s respectively. In order to provide heating the buildings of the Moeil Village, it was not possible to exploit the wells directly with this fluid. For this purpose, four methods were investigated using a geothermal heat pump and river water, which the best method was to increase the flow rate of NWS11 to 10 times using the heat pump, resulted in heating of 300 buildings with a thermal capacity of 7 kW or 24 000 BTU/h. Of course, if the thermal capacity of the buildings is reduced due to reduced area of the infrastructure or the use of building insulations, the number of buildings heated by them will be increased.

Keywords: Building heating, Geo-thermal energy, Moeil village, Sabalan power plant.

1. INTRODUCTION

The use of geothermal energy is generally classified into two categories: electricity generation and direct use. In order to generate electricity from the earth's energy, natural hot water is guided from the drilled wells into the surface, separating them from the steam. This hot steam generates electricity from geothermal power plants by circulating turbines and generators of electricity. Since the present research is intended to explain the direct applications of the geothermal energy of the Meshginshahr Power Plants, the issues of direct use will be followed up.

The world's objective in current state of global climate changes is sustainability in meeting energy needs. Several studies have been conducted to demonstrate the capability of replacing fossil fuels for generating electricity and heat [1] [2]. For this reason, renewable energy is promoted by public and private institutions. Recently, shallow geothermal energy is a practical option to supply energy for heating and cooling, especially in combination with other energy sources. In recent years, shallow geothermal energy has increased more than other renewable energies due to benefits such as less environmental impact, decentralized production, and economic feasibility [3].

Table1 shows the status of installed thermal capacity (MWt), annual energy consumption (TJ/yr) and (GWh/yr) and capacity factor of countries by 2015. The total capacity installed for direct geothermal applications worldwide by 2015, is 70.3 MWt with a cumulative annual growth rate of 7.7%. The total annual energy consumption is 163.3 GWh, with an annual cumulative growth of 6.8%. The global capacity factor is 0.265 (Table 1).

Table1: Summary of statistical data on the use of shallow geothermal energy in the world by the 2015

Country	MWt	TJ/yr	GWh/yr	Load Factor	**Ref.**
Albania	16.23	107.59	29.89	0.21	[4]
Algeria	54.64	1699.65	472.25	0.99	[5]
Argentina	163.60	1,000.03	277.81	0.19	[6]
Armenia	1.50	22.50	6.25	0.48	[7]
Australia	16.09	194.36	53.99	0.38	[8]
Austria	903.40	6,538.00	1,816.26	0.23	[9]
Belarus	4.73	113.53	31.54	0.76	[10]
Belgium	206.08	864.40	24.01	0.13	[11]
Bosnia& Herzegovina	23.92	252.33	70.10	0.33	[12]
Brazil	360.10	6,622.40	1,839.70	0.58	[13]
Bulgaria	93.11	1,224.42	340.14	0.42	[14]
Canada	1,466.78	11,615.00	3,226.65	0.25	[15]
Caribbean Islands	0.10	2.78	0.77	0.85	[16]
Chile	19.91	186.12	51.70	0.30	[17]
China	17,870.00	174,352.00	48,434.99	0.31	[18]
Columbia	18.00	289.88	80.50	0.51	[19]
Costa Rica	1.00	21.00	5.83	0.67	[20]
Croatia	79.94	684.49	190.15	0.27	[21]
Czech Republic	304.50	1,790.00	497.26	0.19	[22]; [23]
Denmark	353.00	3,755.00	1,043.14	0.34	[24]
Ecuador	5.16	102.40	28.45	0.63	[25]
Egypt	6.80	88.00	24.45	0.41	[26]
El Savador	3.36	56.00	15.56	0.53	[27]

Estonia	63.00	356.00	98.90	0.18	[28]
Ethiopia	2.20	41.60	11.56	0.60	[28]
Finland	1,560.00	18,000.00	5,000.40	0.21	[29]
france	2,346.90	15,867.00	4,407.85	0.21	[30]
Georgia	73.42	695.16	193.12	0,30	[31]
Germany	2,848.60	19,531.30	5,425.80	0.22	[32]
Greece	221.88	1,326.45	368.49	0.19	[33]
Greenland	1.00	21.00	5.83	0.67	[34]
Guatemala	2.31	56.46	15.68	0.78	[35]
Honduras	1.93	45.00	12.50	0.74	[36]
Hungary	905.58	10,268.06	2,852.47	0.36	[37]
Iceland	2,040.00	26,717.00	7,422	0.42	[38]
India	986.00	4,302.00	1,195.10	0.14	[39]
Indonesia	2.30	42.60	11.83	0.59	[40]
Iran	81.50	1,103.12	306.45	0.43	[41]
Ireland	265.54	1,240.54	344.62	0.15	[42]
Israel	82.40	2,193.00	609.22	0.84	[28]
Italy	1,014.00	8,682.00	2411.90	0.84	[43]
Japan	2,186.17	26,130.08	7,258.94	0.38	[44]
Jordan	153.30	1,540.00	427.81	0.32	[45]
Kenya	22.40	182.62	50.73	0.26	[46]
Korea (South)	835.80	2,682.65	745.24	0.10	[47]
Latvia	1.63	31.81	8.84	0.62	[28]
Lithuania	94.60	712.90	198.04	0.24	[48]
Macedonia	48.68	601.11	166.99	0.39	[49]
Madagascar	2.81	75.59	21.00	0.85	[50]
Mexico	155.82	4,171.00	1,158.70	0.85	[51]
Mongolia	20.16	340.46	94.58	0.54	[52]
Morocco	5.00	50.00	13.89	0.32	[53]
Nepal	3.32	81.11	22.53	0.78	[54]
Netherlands	790.00	6,426.00	1,785.14	0.26	[55]
New Zealand	487.45	8,621.00	2,394.91	0.56	[56]
Norway	1,300.00	8,260.00	2,294.63	0.20	[57]
Pakistan	0.54	2.46	0.68	0.14	[58]
Papua New Guinea	0.10	1.00	0.28	0.32	[28]
Peru	3.00	61.00	16.95	0.64	[59]
Philippines	3.30	39.58	11.00	0.38	[60]
Poland	488.84	2,742.60	761.89	0.18	[61]
Portugal	35.20	478.20	132.84	0.43	[62]
Romania	245.13	1,905.32	529.30	0.25	[63]
Russia	308.20	6,143.50	1,706.66	0.63	[64]
Saudi Arabia	44.00	152.89	42.47	0.11	[65]
Serbia	115.64	1,802.48	500.73	0.49	[66]
Slovak Republic	149.40	2,469.60	686.05	0.52	[67]
Slovenia	152.75	1,137.23	315.93	0.24	[68]

South Africa	2.30	37.00	10.28	0.51	[69]
Spain	64.13	344.85	95.80	0.17	[70]
Sweden	5,600.00	51,920.00	14,423.23	0.29	[71]
Switzerland	1,733.80	11,836.80	3,288.26	0.22	[72]
Tajikistan	2.93	55.40	15.39	0.60	[28]
Thailand	128.51	1,181.20	328.14	0.29	[73]
Tunisia	43.80	364.00	101.12	0.26	[74]
Turkey	2,886.30	45,126.00	12,536.00	0.50	[75]
Ukraine	10.90	118.80	33.00	0.35	[28]
United Kingdom	283.76	1,906.50	529.63	0.21	[76]
United States	17,415.91	75,862.20	21,074.52	0.14	[77]
Venezuela	0.70	14.00	3.89	0.63	[27]
Vietnam	31.20	92.33	25.65	0.09	[27]
Yemen	1.00	15.00	4.17	0.48	[78]
GRAND TOTAL	70,328.98	587,786.43	163,287.07	0.27	[28]

2. METHOD AND MATERIALS

History of studies on geothermal energy application in Iran, refer to the early 1950s. At this time, preliminary studies were carried out with the collaboration of the National Electricity Company of Italy (ENEL); the results indicated that there is a significant potential for geothermal energy in the northwestern part of Iran. The researchers reported that Sabalan, Damavand, Khoy, Mako and Sahand areas with an area of more than 31,000 km2 are suitable for supplementary studies and utilization of geothermal energy. A total of 11 wells have been drilled at Sabalan power plant in Meshginshahr (Table 2).

Table 2: Characteristics of Geothermal Wells of Sabalan Power Plant

Well	Comp.Date	T.D mMD	Production Casing Size (in)	Production Casing Depth (mMD)	Production Liner Size (in)	Production Liner Depth (mMD)
NWS-1	01-Jun-03	3197	9-5/8	1586	7	3197
NWS-2	25-Jun-03	638	13-3/8	360	9-5/8	638

NWS-3	27-Nov-03	3166	13-3/8	1589	9-5/8	3160
NWS-4	27-Mar-04	2265.5	9-5/8”	1166	7	2255
NWS-5D	31-Aug-08	1901	9-5/8”	750	7	1901
NWS-6D	28-Feb-09	2377	9-5/8”	1250	7	2377
NWS-7D	11-Aug-09	2705	9-5/8”	1313	7	2705
NWS-8D	17-Jan-10	2413.5	9-5/8”	1438	7	2413.5
NWS-9D	07- Dec- 10	2703	9-5/8”	1101	7	2700
NWS-10D	08- Sep-10	2300	9-5/8”	977	7	2300
NWS-11RD	22-Apr-2011	2813	9-5/8”	1286	7	2813
					Total: Km	26.5

2.1. Well NWS-3

The third well of Sabalan power plant, called NWS-3 has a depth of 3176 m. The apparent qualities of the NWS-3 well are illustrated in Fig 1 [79].

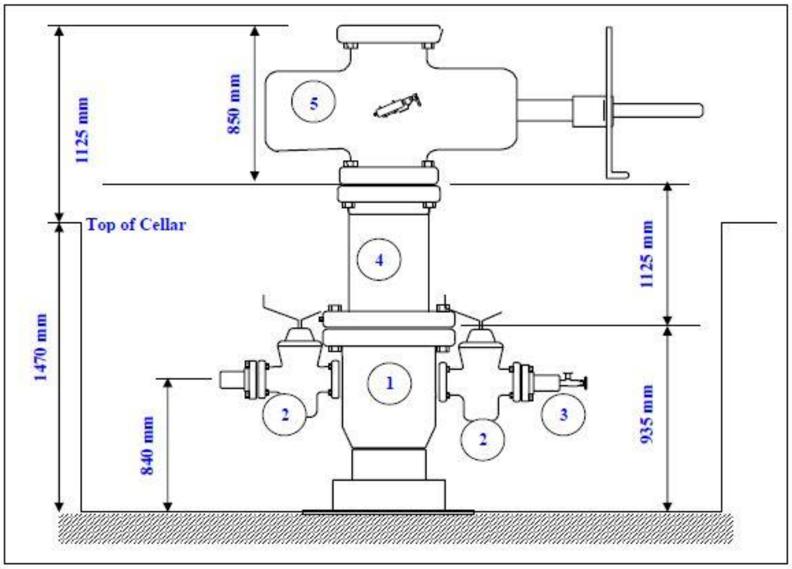

Figure 1: Valve of NWS-3

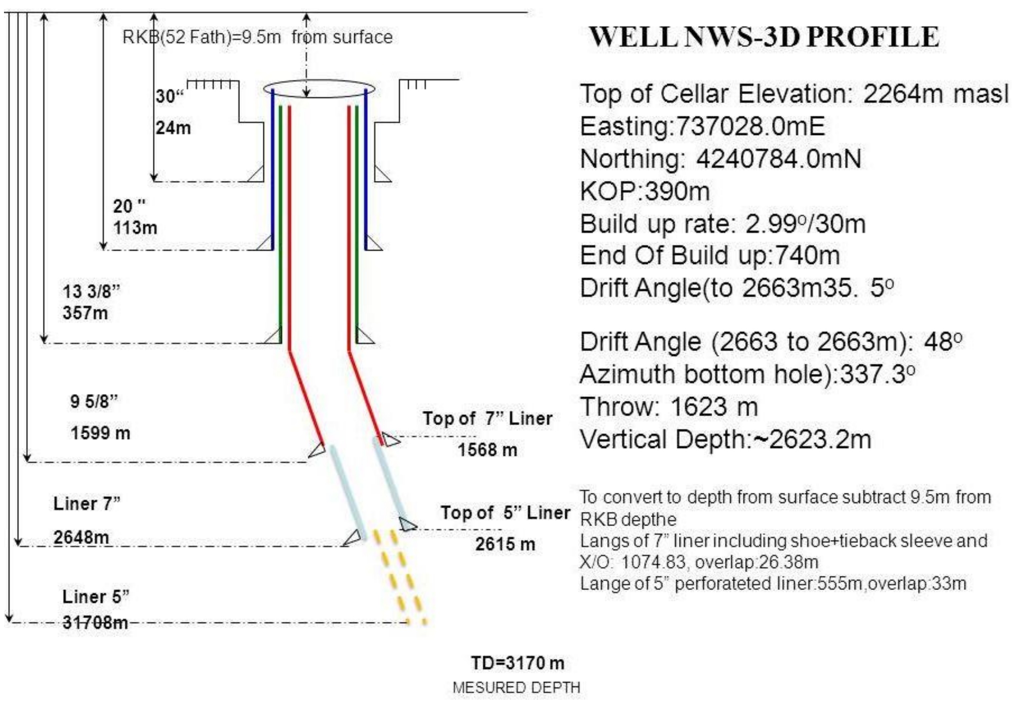

Figure 2: Well NWS-3 profile

The size of the casings and the depth of each of the casings are described in Table 4.

Table 4: The size of the casings and the depth of each of the casings

Formation	Depth-Meter
Dizu	0 to 70
Valhazir	70 to 290
Epa	290 to 660
Monzonite structure	660 to 3000

The shallow area in the well is studied in the intersection between the Dizou and Valhazir Formation at a depth of about 225 m. The main purpose of the well was achieving to the faults, named W1 and W2. Based on the information, we believe that these faults have been cut at depths of 1610 and 2665 m. So, there are permeable areas at these depths

The well is good in terms of thermal slope and almost every 100 meters, a $10^{o}C$ increase has been recorded. Also, due to the fact that there are several permanent hot water springs near the well, it is likely that this well has a higher temperature. The pressure in this well is also based on the hydrostatic pressure of the fluid in the well and is higher than the atmospheric pressure. When the fluid in the wells reaches the depths of the geothermal reservoir, it may also be affected by hot water. This area is mainly acid-sulfate. As seen in Fig. 3, the dominant fluid state in the reservoir is liquid. The maximum recorded temperature in this well is about 210°C at a depth of 2,600 m. The maximum recorded pressure is about 207 bar at the bottom of the well. Therefore, in order to exploit the well, it must be restored. It should be noted that the water level is about 60 m of depth of well.

2.2.Well NWS-11RD

The NWS-11RD wells are the second wells drilled in the geothermal area of northwest of Sabalan, which is about 20 m far from the well NWS-3. This is the 11^{th} well of power plant called NWS-11, and the depth of the well is 2813 m [80].

The maximum temperature recorded at this well is 174°C at a depth of about 1550 m and the maximum recorded pressure is 209 bar at the bottom of well. Every 100 meters, a temperature increase of $9^{o}C$ is recorded from the perspective of thermal slope.

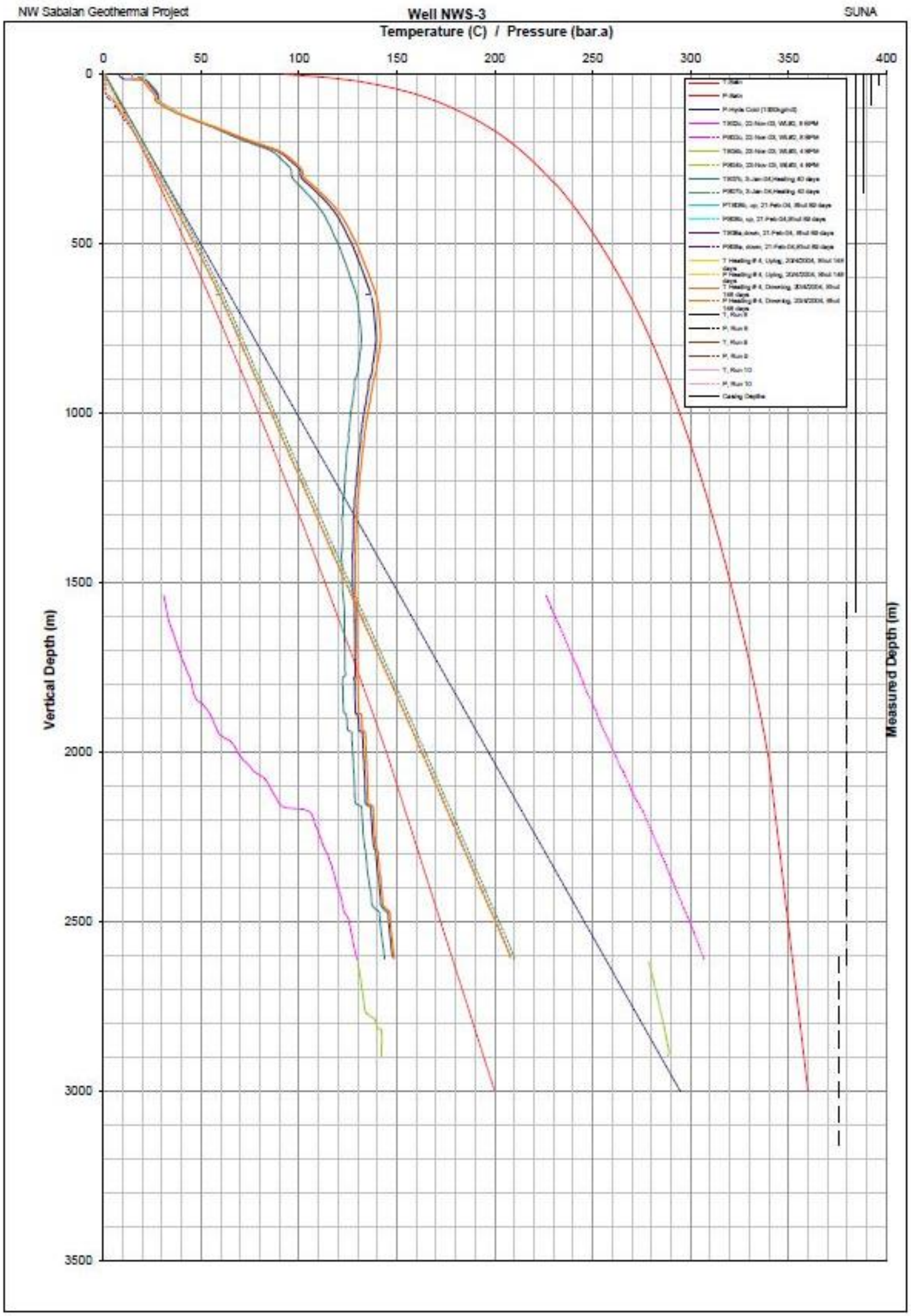

Figure 3: Temperature and pressure profiles versus depth of well NWS-3

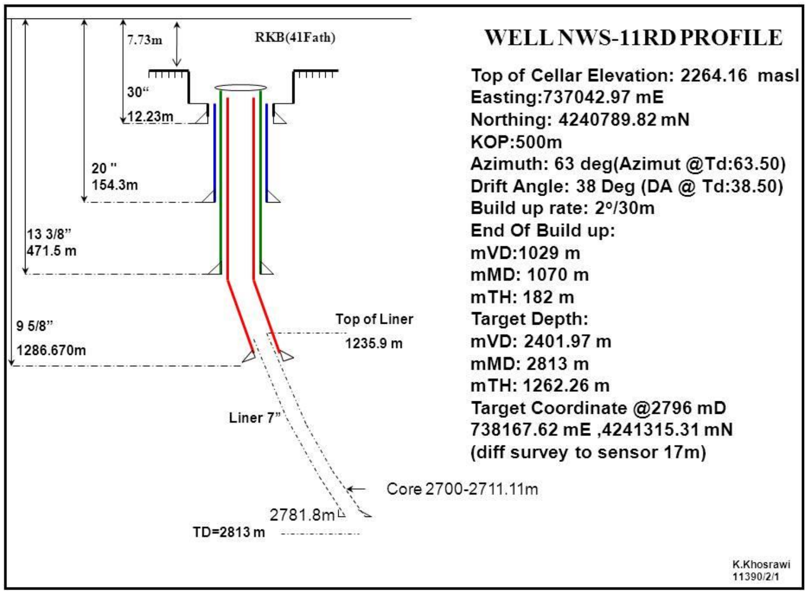

Figure 4: NWS-11RD Well Profile

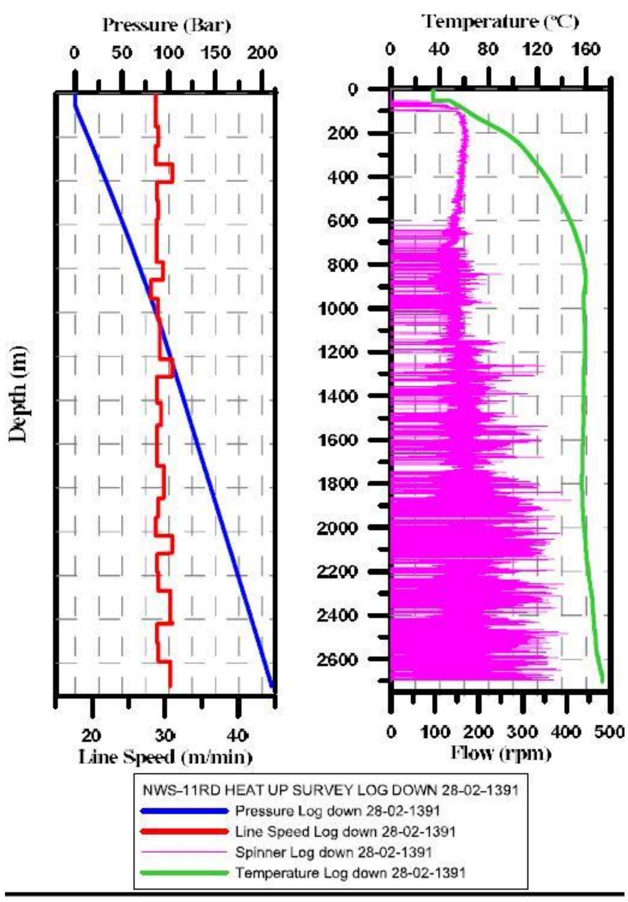

Figure 5: NWS11 Temperature and Pressure Profiles

2.3. Heat pump in the village of Moeil

About 400 households live in the village of Moeil. People are now using the livestock manure that be dried in the summer, to provide heat for their buildings. Gas supply to this village is very costly and non-economic due to its mountainous nature and its distance from the city (25 km). Therefore, NWS3 and NWS11 wells (inefficient in the production of electricity) can be used as a thermal source for a geothermal heat pump system, as well as providing heating for the Moeil Village buildings. Therefore, in this project, the technical feasibility of heating the buildings of the village was investigated by five different methods. The EES software was used for mechanical calculations including heat transfer calculations, thermodynamics, fluids and so on. In thermodynamic calculations and heat transfer, the following formulas were used:

Initially, with the geothermal fluid temperature, which is actually a hot water outlet from the NWS3 and NWS11 wells, and its quality, which is zero because of the lack of vapor in the fluid, we can use the technical facilities of EES software or tables Calculate the fluid enthalpy thermodynamics.

h_w11=ENTHALPY(Water,T=T_w11,x=x_w11) (1)

h_w3=ENTHALPY(Water,T=T_w3,x=x_w3) (2)

After the above calculations, we sum up the total volume of the two-well fluid flow.

m_w=m_w11+m_w3 (3)

The total enthalpy is calculated using the following formula

h_w=(h_w11*m_w11+h_w3*m_w3)/m_w (4)

As a result, based on the thermodynamic tables and software features, the total fluid temperature can be obtained

T_w=TEMPERATURE(Water,h=h_w,x=x_w) (5)

Accordingly, the relations governing the way in which river water combines with the total geothermal fluid will be as follows.

h_r=ENTHALPY(Water,T=T_r,x=x_r) (6)

m_s=m_w+m_r (7)

h_s=(h_w*m_w+h_r*m_r)/m_s (8)

T_s=TEMPERATURE(Water,h=h_s,x=x_s) (9)

Here:

h_w3	Enthalpy of well 3
T_w3	Fluid temperature of well 3
x_w3	Fluid quality of well 3
h_r	River enthalpy
T_r	River water temperature
x_r	River water quality
m_s	Flow rate of geothermal heat pump
h_s	Enthalpy of geothermal heat pump
h_w11	Enthalpy of well 11
T_w11	Fluid temperature of well 11
x_w11	Fluid quality of well 3
m_w	Total flow rate of Geothermal
h_w	Total enthalpy of geothermal fluid
T_w	Total geothermal fluid temperature
x_w	Total geothermal fluid quality
T_s	Fluid temperature of the heat pump

2.3.1. Heating methods using geothermal energy

2.3.1.1. Direct heating

The first method is the direct application of the fluid outlet from the geothermal wells, in which the fluid is guided directly into the houses and heated by the radiator inside the building. This method is not applicable for this project due to the low flow rate of the geothermal fluid and its temperature. Based on geothermal technical charts, the minimum required temperature for direct heating by geothermal fluid is 80°C [41].

2.3.1.2. The combination of well flow with river water

In some geothermal sites, the river water can be used to increase the flow rate if the flow temperature of the outlet from the well is high and the flow rate is low and the river water resources are near the well. Although the river Khyav is located on the site of Meshgin City, but the output flow temperature of the NWS3 and NWS11 wells is very low and it is technically impossible to use this method.

2.3.1.3. Usage of geothermal heat pumps and river

In this method, the geothermal wells are used as heat sources (heating mode condensers) for the geothermal heat pump. In this case, according to total flow rate of two wells (18.6 lit/s) and its composition with the river water (5°C), a water pump should be used to exploit the river at 131.4 lit/s so that a water with a temperature of 10.24°C will be provided for a geothermal heat pump. In this case, based on the technical specifications of the geothermal heat pump, it is possible to heat 50 residential units with the required heat capacity of 24,000 BTU/h (7 kW). In this case, the geothermal fluid at 47.43°C is combined with river water and is transferred to a building in a water transfer network and the heat pump provides heating [41].

2.3.1.4. Usage of the submersible pump

Using a submersible pump, we try to increase the discharge rate of the well and examine the effects of this increase on the performance of the system of thermal heat pump system.

2.3.1.5. Increasing fluid temperature

If the water is extracted from the well depth using insulating tubes for increasing temperature of the outlet flow from the well, then it can be heated more buildings.

3. RESULTS AND DISCUSSION

3.1. Results of NWS-3 Well Injection

The main results of this operation are as table 5.

Table 5: Injection Results of Well NWS-3

BPM	*Flow rate (ls-1)*	*Temperature (°C)*	*Pressure (MPa)*	*Spinner (RPS)*
4	*10.6*	*108*	*25.70*	*-4*
8	*21.2*	*74*	*27.90*	*3*
12	*31.8*	*49*	*28.85*	*-2.8*
16	*42.4*	*34*	*29.41*	*-2.8*

So the permeability coefficient of this well is 12 lit/s per MPa.

Injectivity index: $II = \frac{\Delta Q}{\Delta P}$

In the studied on well, production operations have never been performed to obtain the production parameters, but based on a field belief, usually the number obtained for the amount of injection into a well can be considered as production coefficients. So, with this assumption, 12 lit/s per MPa is as a factor for producing this well. However it is strongly recommended that the actual amount be replaced after the test.

3.1.1. Test of productivity index

This test is used to measure the geothermal capacity (PI) of the geothermal reservoirs which is the ratio of flow rate to pressure drop over the life of the reservoir. This indicator reflects the inherent capacity of the reservoir for production. The higher its value indicates the high capacity of the reservoir in the fluid flow which ultimately gets through the well.

3.1.2. Well acidizing

Acidizing the geothermal wells is used to increase the production or injection of geothermal wells. The ways to achieve this goal are as follows:

- Hydraulic fracturing
- Acidizing of Source rock
- Re-drilling

In order to determine the performance of a well, the profit index (PI) can be calculated from the reservoir data, and the realistic index of actual utilization of the PI to be considered as a performance criterion for wells. According to field observations, usually wells with a flow rate of less than 75% of their ideal flow can be a good candidate for acidizing. Also, in the case of low pressure or low permeable wells, acidizing operations can't be economically a good method for these wells. But in these cases, the creation of an artificial hydraulic fracturing is a more appropriate method.

3.1.3. Usage of the submersible pump

If the submersible pump is placed inside well No. 3 and the flow rate is increased up to ten times, the increase in the temperature required for the geothermal heat pump reaches 20.84°C, which in this case, combined with the river water with a flow rate of 490 l/s, it can provide a total water temperature of 10.33°C and a flow rate of 541 l/s for a heat pump; in this case, heating can be provided to 180 homes with a capacity of 7 kw of heat.

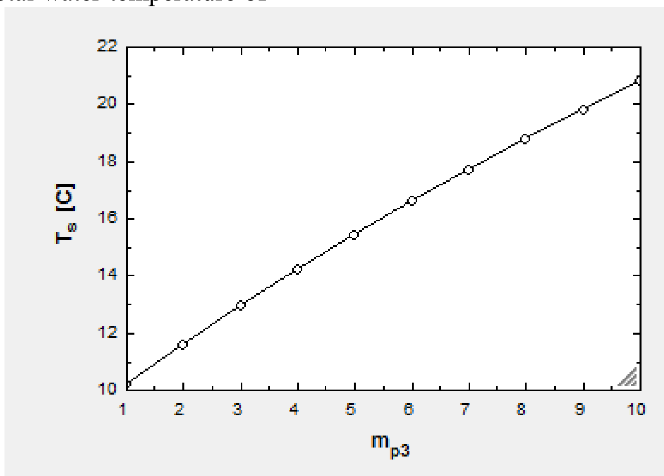

Figure 6: Increase in the fluid temperature of the heat pump versus increasing NWS3 flow rate up to ten times

3.1.4. Increasing fluid temperature

If it is considered to get water with higher temperature from well No. 3, we should take the fluid with insulated pipes from a depth of 200 m (according to Fig. 3). In this case, the temperature of the fluid outlet from well No. 3 will be approximately 210°C with a flow rate of 3.6 lit/s, in which case the total amount of geothermal fluid with a flow rate of 18.6 lit/s will have a temperature of 75.4°C. With a water flow of 221.4 lit/s, the water needed for the heat pump can be supplied at a temperature of 10.44°C and 240 lit/s, which will provide the heat needed for heating 80 buildings.

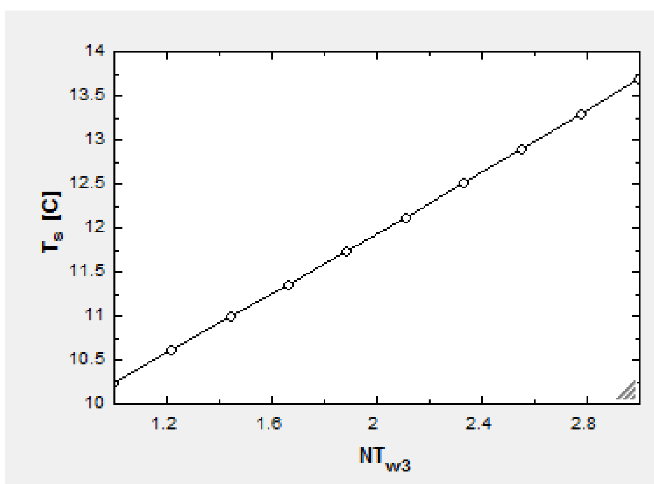

Figure 7: Increase in fluid temperature of the heat pump source versus increasing the temperature of the output fluid from the NWS3 well to 3 times

3.2. Results from Well Tests NWS-11R

In the well NWS-11RD, the injection or production test has not been performed for the following reasons:

1. Fast transfer of drilling rig after completion
2. Low permeability
3. Failure to obtain proper results from well during drilling.

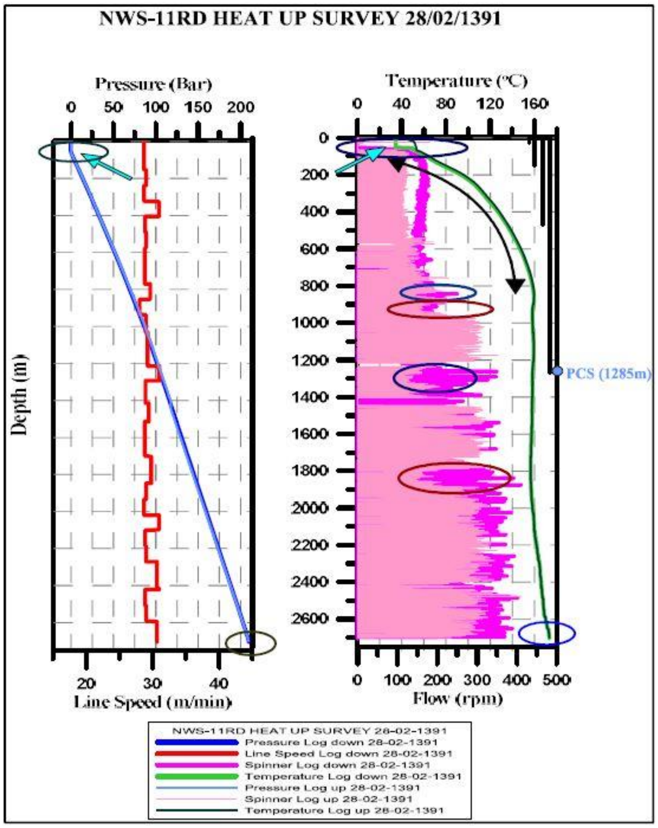

Figure 8: the chart of flows in the well

The tests were carried out in the form of a heat up test on the well, and in these tests it was determined that the well could produce about 5 lit/s per atm, but this production was not constant and the behavior of this well was like boiling springs, and almost every 50 seconds, an irregularly generated production occurs in the well at the head of the well. It is also apparent from the results of the diagramming that the flows are at an acceptable level (approximately 15 lit/s) at the bottom of the well connected to the reservoir. By installing the in-well pump, this well can be used alternately, or it can be used by the acidizing methods like well NWS-3.

3.2.1. Usage of the Submersible Pump

If the flow rate of the well NWS-11RD is increased up to ten times by using the pump, the total geothermal fluid will be supplied at a rate of 153.6 lit/s and at a temperature of about 25.27°C. By increasing the flow rate of the river water by 746.4 lit/s, the required water requirement for the geothermal heat pump can be 900 lit/s. And with this amount of water, which has a temperature of 11.41°C, we can provide heating for 300 residential units.

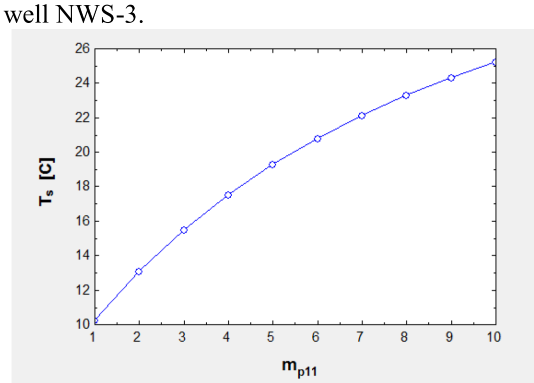

Figure 9: Increased fluid temperature of the heat pump source by increasing the flow rate of the NWS11 well to ten times

By comparing Figs. 6 and 9, it can be said that the increase in the flow rate of well NWS11 will provide a better performance for heating more buildings.

3.2.2. Increasing Fluid Temperature

If the tube is placed in well No. 11 and the water is provided at a temperature of 400 ° C (120°C), the geothermal fluid temperature will be 115.2°C with a flow rate of 18.6 lit/s. In this case, using river water with a flow rate of 341 lit/s, it is possible to provide water with a flow of 360 lit/s and a temperature of 10.69°C for the geothermal heat pump system. This amount of water will be capable of heating up to 120 units of building with a capacity of 7 kW.

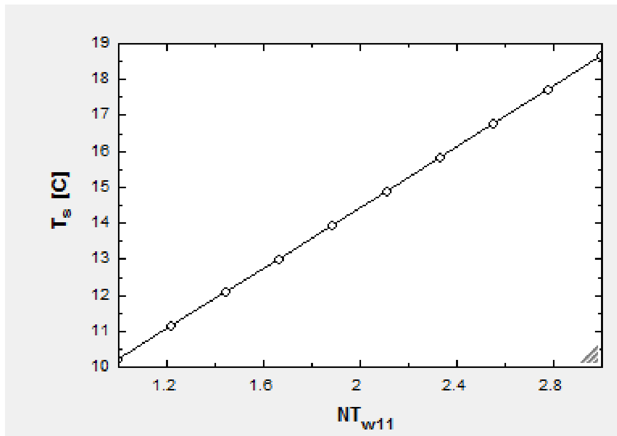

Figure 10: Increased fluid temperature of the heat pump source versus increasing the temperature of the outlet fluid from the NWS11 well to 3 times

3.3. The results of the Drilling Section

NWS-3 and NWS-11RD wells have the following production characteristics:

Table 6: Production Specifications of wells

NWS-11RD		**NWS-3**	
42°C	Outlet temperature of fluid	70°C	Outlet temperature of fluid
3Atm	Outlet Pressure of fluid	3Atm	Outlet Pressure of fluid
5 lit/s per Atm	Flow rate	1.2 lit/s per Atm	Flow rate

4. CONCLUSION

By conducting geological studies and reviewing information collected during drilling at NWS3 and NWS11 wells, as well as carrying out reservoir engineering studies and tests, it was found that the Fluid outlet temperature of the NWS3and NWS11 wells was 70 ° C and 42 respectively. Also flow rate of the NWS3and NWS11 wells was about 3.6 and 15 lit/s respectively.

It was not possible to directly use of wells to heat the buildings of the Moeil village. Therefore, using a geothermal heat pump and river water, four methods were considered which the best method was increasing the flow rate of well NWS11 to 10 times using the pump, so the heating of 300 buildings were provided with a thermal capacity of 7 kilowatts Or 24,000 BTU per hour.

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