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Technical and Economic Analysis of a Wellhead GPP and 20 MWe GPP for Meshkin-Shahr Geothermal Power Plant

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ABSTRACT

Eleven wells have been drilled in Meshkin-Shahr near Sabalan Mountain in the north-west of Iran. Seven are production wells, one is a reinjection well and three wells are out of reservoir. According to the data from well testing, the mass flow of the wells is 30-70 kg/s and the temperature is between 130-170 °C. The result of this calculation shows that it will be possible to generate 30 MWe or 35 MWe from these wells. Two scenarios have been explored for Sabalan geothermal field. The first scenario is installing a wellhead power plant to get some more experience about the continuous production of geothermal fluid and the second scenario is installing 20 MWe to provide assurance of securing the required amount of geothermal fluid. In this report, the technical and economic possibility of geothermal power plants for 5 or 20 MWe will be calculated.

1. INTRODUCTION

Iran has an abundance of fossil fuels in the form of oil and gas. It has the second largest natural gas reserves in the world and also uses oil reserves. In addition to this, Iran has good potential for renewable geothermal, wind, and solar energy that should be used for the benefit of its people. The main benefits of renewable energy use in Iran are:

1. Better overall utilization of its energy sources;
2. Saving fossil fuel for export to other countries or for future generations;
3. These are environmentally benign energy sources, with low CO_2 emissions.

Iran has fourteen vast areas with good potential for geothermal utilization, as shown in Figure 1. One such area is the Meshkin-Shahr geothermal field. Ten exploration wells and one injection well have been drilled to determine the parameters of the reservoir and develop the field. Seven exploration wells have been tested.

2. MESHKIN SHAHR GEOTHERMAL POWER PLANT

According to the well test data for the seven production wells, each well has 5 to 7 MWe potential for generation of electricity and according to the reservoir studies it will be possible to generate 20- 35 MWe from the production wells. The geothermal department in the Renewable Energy Organization of Iran (SUNA) explored tender documents for the geothermal power plant. It is necessary to choose between a single flash condensing geothermal power plant (GPP) with 20 MWe capacity or wellhead geothermal power plant. The investment cost of the 20 MWe is much higher than the 5 MWe, but the pay back of the 5 MWe is lower than the 30 MWe.

There is not any long time production experience in Iran. So the 5 MWe geothermal power plant tender documents have been collected and in 2015 and 2016 the first geothermal electricity will be generated from Sabalan geothermal field.

To increase knowledge and experience in geothermal power generation and control of scaling caused by the geothermal fluid in a well, engineering, procurement and construction (EPC) of a 5MWe single flash condensing power plant has been explored in the geothermal department at SUNA.

3. MODELING OF SINGLE FLASH CONDENSING GEOTHERMAL POWER PLANT

Single flash steam technology (Figure 2) is used where the hydrothermal resources are in liquid form, the fluid goes into a separator which is held at a lower pressure than the fluid, causing it to vaporize (or flash) rapidly to steam. The steam is then passed through a turbine coupled to a generator as for dry steam power plants. Cooling water is pumped to the condenser to generate more electricity and the brine of the geothermal fluid from the separator is pumped to direct use applications or to the reinjection wells. The T-S diagram (Figure 3) has been used to determine the amount of power that can generated from the geothermal power plant.

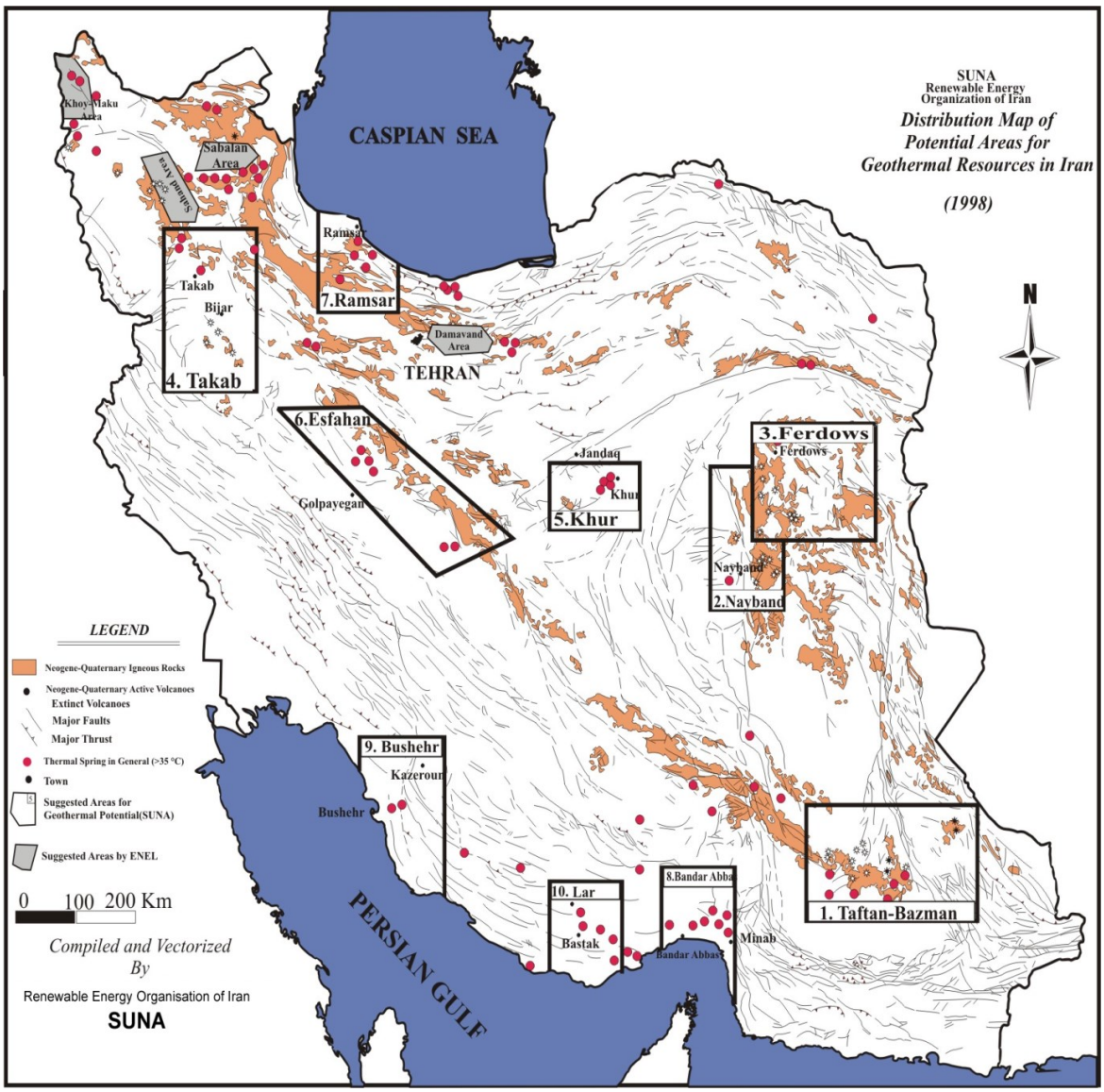

Figure 1: Potential of Geothermal in Iran

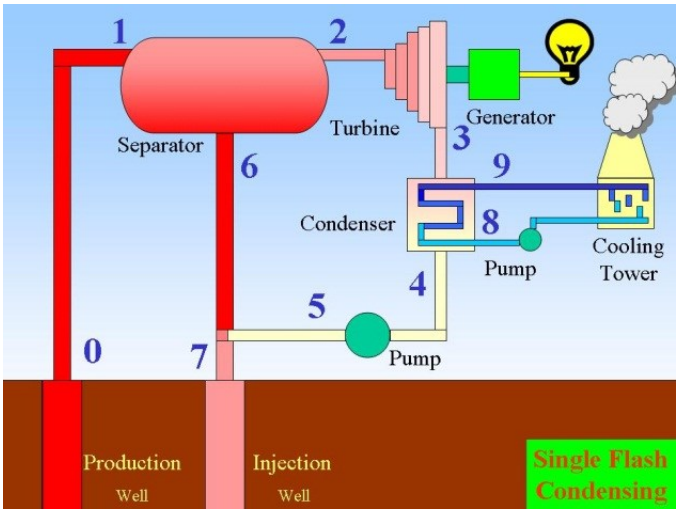

Figure 2: Schematic of Single Flash Condensing Cycle Geothermal Power Plant

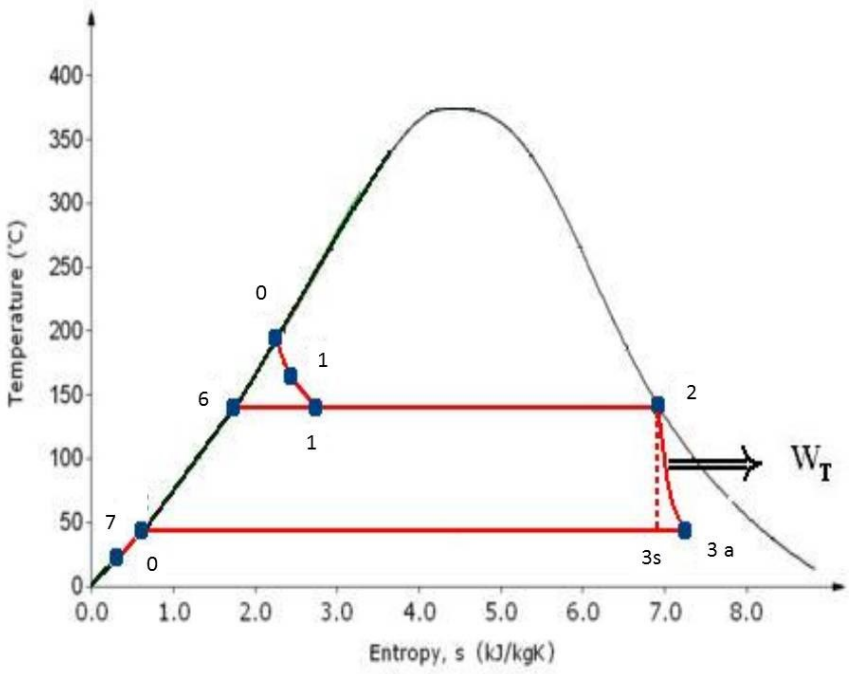

Figure 3: T-S diagram of the geothermal power plant

4. TECHNICAL CALCULATIONS

Thermodynamic modeling has been done for both geothermal power plants. Engineering Equation Solver (EES) software has been used to determine the thermodynamic parameters such as: temperature, pressure, enthalpy, entropy, fluid quality and some physical parameters such as: steam mass flow and brine mass flow.

4.1 Technical Calculation for Wellhead GPP

For determining the thermodynamic parameters, some input data had been collected in well test process and some of the input data have been guess. These data have been shown in Table 1.

Table 1: The input data for thermodynamic modeling for well heat GPP

Name of Data	Amount	Unit
Well Heat Pressure	9	bar
Well Heat Temperature	175	°C
Enthalpy	1200	kJ/kg
Total Mass Flow	60	kg/s
The Efficiency of the Turbine	90	%
The Efficiency of the Generator	90	%
Pressure Drops in Separator	6.5	bar

According to the calculation and EES model, it is possible to generate 6.755 MWe from a well in Sabalan geothermal field, but the net power generation of the power plant will estimated about 5.5 MWe to 6 MWe.

It has been calculated that 14 to 15 million US$ are needed to complete the EPC contact for whole geothermal power plant project.

4.2 Technical Calculation for 20MWe

The input data for the 20 MWe geothermal power plant has been collected in Table 2.

Table 2: The input data for thermodynamic modeling for 20MWe GPP

Name of Data	Amount	Unit
Well Heat Pressure	12	bar
Well Heat Temperature	175	°C
Enthalpy	1200	kJ/kg
Total Mass Flow	200	kg/s
The Efficiency of the Turbine	90	%
The Efficiency of the Generator	90	%
Pressure Drops in Separator	8	bar

According to the calculation and EES model, it is possible to generate 23.061 MWe from Sabalan geothermal field with four production wells, but the net power generation of the power plant is estimated to be about 20 MWe to 21 MWe.

It has been calculated that 42 to 45 million US$ are needed to complete the EPC contact for whole geothermal power plant project.

5. ECONOMIC CALCULATIONS

The Ministry of Power has established a renewable energy electricity production law and in this law every year, the price of electricity that has been produced from renewable resources is compared with the other fossil foul power plants. In 2014 the price of renewable electricity production is about 0.14 to 0.15 US$ per kWh. If the plant uptime for both power plants is estimated as 7446 hours per year, the amount of energy produced by the wellhead power plant is about 41 to 44 GWh/y and the energy production from the 20 MWe plant is estimated to be about 149 to 156 GWh/y. The revenue from the wellhead GPP is about 5.7 to 6.1 million US$ per year and the revenue of the 20 MWe is about 20.8 to 21.8 million US$ per year. This means the payback of the wellhead geothermal power plant is about 2.5 years and the pay back of the 20 MWe geothermal power plant is about 1.9 years.

6. CONCLUSION

Technical modeling of the wellhead geothermal power plant shows that the capacity of the GPP is about 5.5 MWe to 6 MWe and the capacity of the 20 MWe GPP is about 41 to 44 GWh/y. It is estimated that the price of the wellhead GPP is about 14 to 15 million US$ and the payback is about 2.5 years if the revenue of the wellhead GPP is around 5.7 to 6.1 million US$ per year.

These calculations for the geothermal power plant with 20MWe capacity show that the investment cost of this power plant is about 42 to 45 million US$ and that this power plant will generate about 149 to 156 GWh/y with revenue of 20.8 to 21.8 million US$ per year and payback of about 1.9 year.

Installing a 20MWe geothermal power plant will be more economic than the wellhead project, but in Iran nobody has experience about the long-term continuous production of geothermal fluid. So the Renewable Energy Organization of Iran (SUNA), on behalf of the Ministry of Power, has explored tender documents for the 5MWe geothermal power plant.

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