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Evaluation the geothermal power technologies suitable for geothermal reservoirs in the Northern provinces of Vietnam

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----------*ABSTRACT*----------
Vietnam is located between the two rings of "Ring of Fire around the Pacific" and "Belt of Alpes-Himalaya". With only average heat flow 50-80 mW/m^2, there is a number of points coinciding with the fault zone which have reached over 100 mW/m^2, including the northern provinces of Vietnam. The temperature deep under the reservoirs are determined by the geochemical thermometer method, which reaches from 136^{0}C to 170^{0}C. These geothermal sources could allow the construction of geothermal power plants with a capacity of 4.2 MWe to 17.4 MWe. However, geothermal energy sources are still at the survey and potential evaluation stage. Currently, Vietnam's geothermal source is still limited to direct use, geothermal power generation has never been considered. Therefore, we will carry out research and propose suitable technologies to produce geothermal electricity for geothermal reservoirs in the northern provinces.

KEYWORDS*- Geothermal, geothemal technology, powergeothemal, binary technology, Vietnam geothemal.*

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I. INTRODUCTION

Geothermal energy is a clean and renewable resource that provides a huge amount of energy. According to the survey and evaluation of potentials of experts, Vietnam's geothermal is evenly distributed throughout the territory with low and medium heat levels. However, up to this point, Vietnam has not had any geothermal power projects in operation.On the global heat flow map, Vietnam is located in the region with a heat flow of 50-80 mW/m2, which means it is only average.Currently, the geothermal energy source of Vietnam is only used directly, such as exploiting hot water below 100°C to supply heat for drying agricultural - forestry products. There are a few points that are exploited hot heat to supply power stations with a capacity of several hundred KW, to meet the needs of energy on the spot. In addition, the storage tanks are exploited for heating the plant nursery, breeding, industry, households.Therefore, our team has conducted an assessment of current geothermal mining technologies in the world. After that, we analyzed and selected the most suitable technology to exploit geothermal energy - binary technology - to produce electricity for geothermal resources in Vietnam.

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II. MATERIAL AND TECHNOLOGY

1. Material

Vietnam is located between two belts "Ring of fire around the Pacific" and "Belt of the Alpes-Himalaya".On the global heat flow map, Vietnam is located in the region with a heat flow of 50-80 mW/m^2, which means it is only average. The average heat current in the North reaches 68-90mW/m^2, in the South - common in the range of 40-80mW/m^2. Only a few points coincide in the fault zone can reach more than 100 mW/m^2, such as the southeastern part (Thai Binh) of the Hanoi basin: 110-120mW/m^2, Hue basin: 106-143mW/m^2, Quang Ngai basin: 90-120mW/m^2, Kon Tum basin: 86-108mW/m^2. Expression of thermal anomalies are hot water veins on the ground and in shallow boreholes, but only localized and not enough to form a large geothermal field.

The thickness of the territorial lithosphere in Vietnam changes in the range of 85-95km in the mainland, which means that the mantle's influence is not large, expressed in the heat flow and geothermal gradient values on the regional scale. medium. In terms of seismicism, due to its special tectonic position, the territory of Vietnam has not suffered from catastrophic earthquakes, but is also a place where there are often catastrophes, mostly moderate with level 5.0-5.5 Richter level, only a few regions reach 5.6-7.0, concentrated in the meandering mountainous Northwest, North Truong Son, Southern Truong Son and the West East Sea.

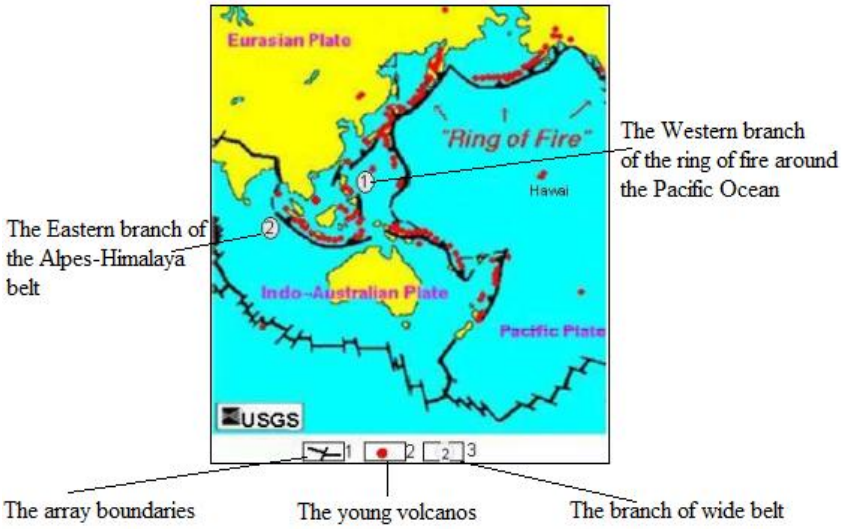

Figure 1. Vietnam's territorial position on the planetary dynamic belt map.

According to research results as of 2008, Vietnam has discovered 264 hot water sources from 30 degrees Celsius or more, distributed vertically from North to South. Concentrated in the Northwest and South Central regions. There are 30 sites with a capacity of 340 MWe have been identified as being capable of power generation.

Temperature class	Regions							Add by heat level	% compared with the whole
	North West	East Northern	Northern Delta	North Central	South Central Coast	South East	South West		
1. Warm (30-40^{0}C)	36	5	6	7	28	5	48	135	51,5
2. Medium hot (41-60 ^{0}C)	39	2	4	12	22	1	2	82	31,1
3. Very hot (61-100^{0}C)	5	3	2	7	25	1	0	43	16,3
4. Too hot (> 100^{0}C)	0	0	3	1	0	0	0	4	1,5
Add by region	80	10	15	27	75	7	50	264	
% compared with the whole	30,3	3,8	5,7	10,2	28,4	2,7	18,9		100%

Table 1. The statistics of hot water sources in Vietnam

In the Red River basin, there are many hot water detection boreholes, especially deep holes in Thai Binh and Nam Dinh that found "too hot" water (from 100 – 150^{0}C) at depth 2-3 thousand meters. According to the development of geological investigation and search for oil and gas, the number of drilled holes meeting hot water will surely increase. In the Southern Delta, in the boreholes mostly found warm water. A very interesting phenomenon is that in Le Thuy (Quang Binh), a hot water source of 100^{0}C appeared on the ground, when drilling to a depth of 55m, the temperature increased to 105^{0}C.

II. TECHNOLOGY

Most power plants use steam to generate electricity. Whereas factories use fossil fuels to burn coal, oil or gas to boil water. Current geothermal plants using steam are usually produced using "flash" technology - that is, reducing the pressure of a liquid from a geothermal reservoir. Today's geothermal power plants can use water in the steam phase, a combination of steam and liquid phase or just liquid phase. The choice of the plant depends on the depth of the reservoir, temperature, and pressure of the entire geothermal source at that place.

There are three types of plants: flash stream, dry steam, and binary plants. All current geothermal mining technologies use the retrieval method to exploit sustainable resources.

2.1 Flash stream plants

Geothermal sources usually contain hot liquid (water) and steam (steam). Steam plants make up about two-thirds of today's installed geothermal capacity. Exploitation of a reservoir with a temperature of 180^{0}C.

In a high temperature steam reservoir, the boiling liquid water component accelerates when the pressure is reduced. The steam is sent to the turbine to generate electricity. The remaining hot water can be re-accelerated twice or thrice at gradually lower temperature and pressure to obtain more steam. The cooled and condensed water is returned to the storage tank through drilled wells. The mixed cycle superfluid steam plants use heat from the water of the tanks in the binary plants to produce more energy before return.

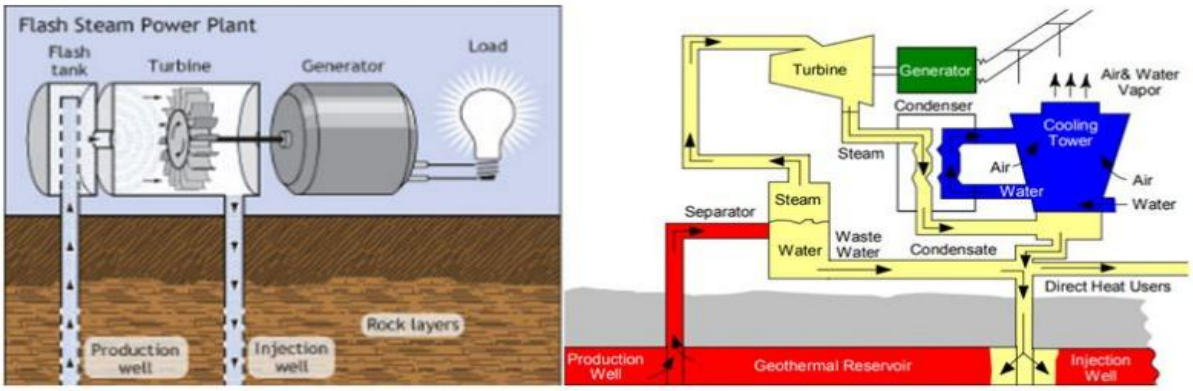

Figure 2. Flash Steam Power Plant Diagrams and Single Flash Steam Power Plant Schematic (*from: Geo-Heat Center and U.S. Energy Dept*)

2.2 Dry stream plants

Dry steam plants make up about a quarter of today's geothermal capacity. Direct use of dry steam is led from mining wells to turbines. It is easier to control the amount of steam in response to fluctuations in power generation in flash stream plants. Due to the constant flow in the reservoir it helps to avoid breaking the gravity of the liquid phase. In dry steam plants, the condensate is usually refilled into the tank or used for cooling.

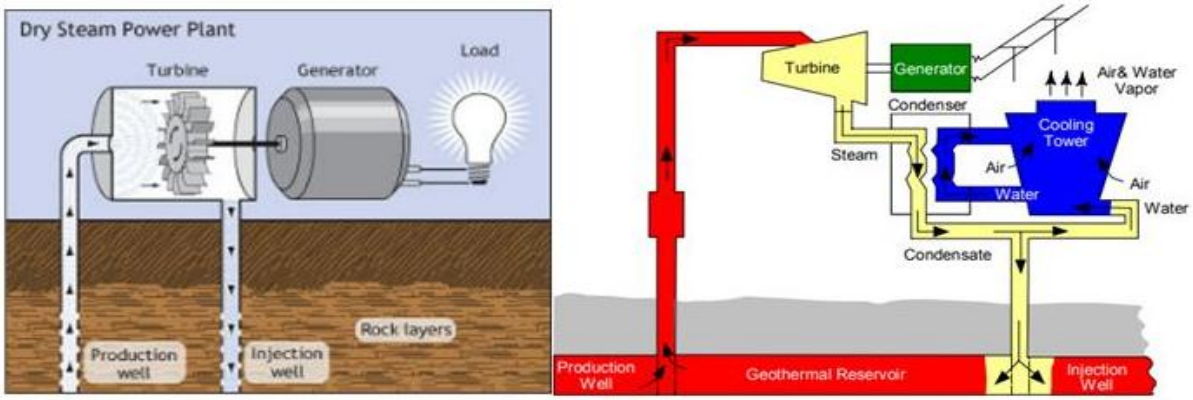

Figure 3. Dry Steam Power Plant Diagram and Power Plant Schematic(*from: Geo-Heat Center and U.S. Energy Dept*)

2.3Binary plants

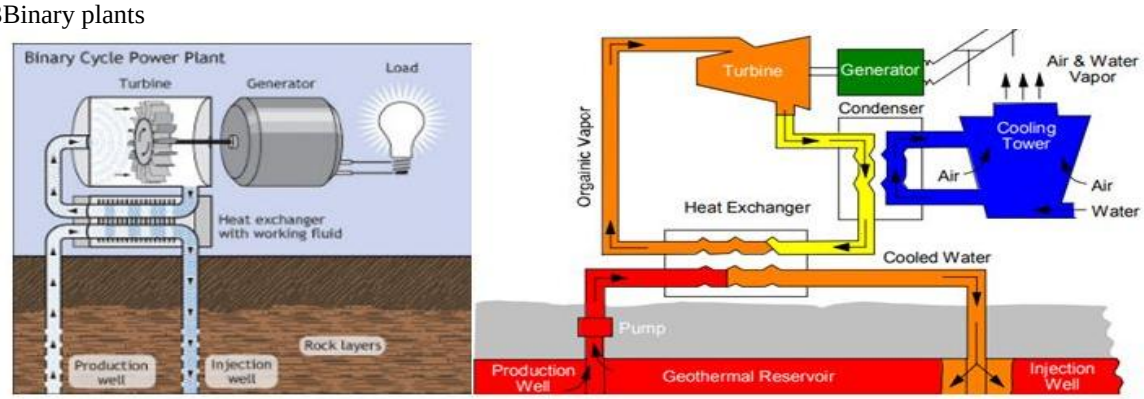

Figure 4. Binary Power Plant Schematic and Power Plant Diagrams(*from: Geo-Heat Center and U.S. Energy Dept*)

Generating units use two cycles to form the group of the fastest growing geothermal plants. Because of the nature of the technology, it is possible to use low to medium temperature resources. In two cycle plants use either the Rankine cycle or the Kalina cycle. Usually operates with low temperatures from 73^0C to 180^0C. In these plants, heat is obtained from a geothermal liquid through a heat exchanger to evaporate natural fluids with a low boiling point to run the turbine.

Although both cycles were developed in the mid-20th century, the ORC cycle is the mainstream technology used for low temperature sources. The active Kalina cycle has higher cycle efficiency than the normal ORC cycle. The low temperature geothermal water leaves the heat exchanger to be pumped back to the reservoir in a closed loop. Today two cycle plants have 11% of global installed capacity and 44% of geothermal plants.

III. RESULTS

After researching and analyzing the technology, we have divided the temperature and liquid phase of the reservoir according to the purpose of use. In this study we only focus on the purpose of using geothermal energy for electricity production. Hence, it is recommended that investors choose and use power generation technology that is suitable for that geothermal source.

According to the analysis in Table 1, the geothermal source of Vietnam is mainly in the low and middle temperature class. Existing phase form is liquid, hot spring. With geothermal sources discovered and measured, there are 4 reservoirs reaching temperatures above 100^0C and they are concentrated in the North. The tanks reached a temperature of 61 - 100^0C, discovered 17 reservoirs in the northern provinces.

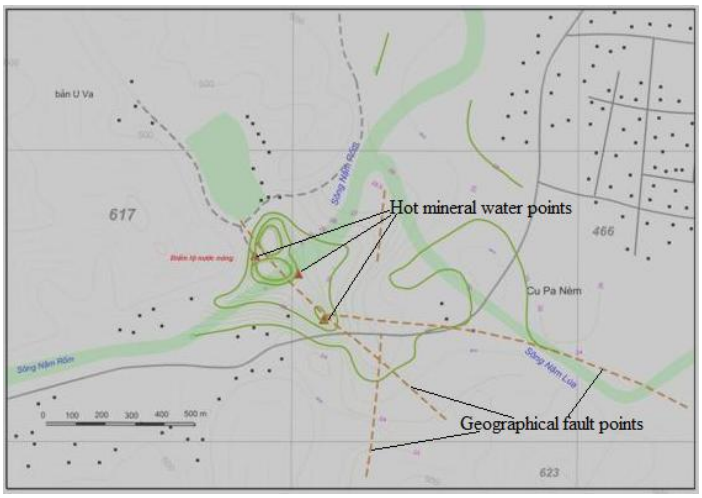

Figure 4. Geothermal field diagram of U Va region, Dien Bien province

The main application of low temperature geothermal systems is urban heating because hot water will be used directly from 50-130^0C. That is the usual way of some countries in the world as well as in Vietnam.However, our research purpose is to find the right technology to generate electricity from geothermal resources in Vietnam.For power plants to operate efficiently, geothermal resources must be 120-150^0C or more. Normally the water from the heat source is pumped to the steam separator, the separated steam is sent to the steam turbine to run the generator. The steam behind the turbine is condensed and pumped back into the ground with the condensate in the steam separator.

In geothermal systems with temperatures as low as 150^0C, the generation of electricity directly from steam is often not suitable. However, if the temperature is above 90^0C, a warm liquid can be used to evaporate a second liquid with a lower boiling point (such as freon, isobuthane or ethyl chloride). Hence steam is obtained for indirect electricity generation. But the efficiency of this process is quite low.

In the mixed scheme, hot water with a temperature less than 200 degrees Celsius is used, which is the most abundant source of hot water in most geothermal regions. The hot water underground is brought up in a "super liquid" form, with a low boiling point, is passed through the heat exchanger chamber. The thermal energy of the geothermal water evaporates the water in the heat exchanger chamber, and the high pressure steam rotates the electric turbine. The advantage of this model is that it can limit the situation that can cause harm to the environment (albeit very light, compared to thermoelectricity from fossil fuels). This is a closed system, so there is no waste entering the atmosphere or soil - deep underground water often contains toxic gases such as SO_2, CO_2 and contains trace elements such as Arsenic, Mercury, Antimony... Hot water has heat. Moderate elevation

is the most common source of geothermal heat, with the most abundant potential, so in the future most geothermal power plants will operate under this principle.

In Vietnam, we propose to investors that exploiting geothermal energy to produce electricity should use two cycle technology - binary technology. Because this technology is suitable for geothermal tanks with low and medium temperatures from 73^0C - 180^0C.This type of technology is available and has been successfully applied in many countries around the world. In addition, this technology selection is suitable for the economic conditions and development status of the geothermal industry in Vietnam.

The two cycle technology -binary technology - has two particularly important factors: First, geothermal power is of great significance in protecting the environment; Almost no exhaust gas, dust, and noise. Secondly, the geothermal power plant has a large capacity and is stable, convenient for production and living needs. Construction of the Geothermal Power Plant will take advantage of the natural potentials from the on-site hot water mines and also contribute to improving the daily life of people living in the area. During operation, the Geothermal Power Plant also helps to improve the surrounding environment that can be used to develop tourism.

IV. CONCLUSION

Geothermal energy source is still at the stage of prospecting and evaluating its potential in Vietnam. There are also a number of projects set up for the purpose of exploiting this natural energy source as in Ha Tinh, but currently, the assessment studies are not enough convincing grounds for the technical evaluation phase of a mining project. waterfall. Therefore, information about geothermal energy sources in Vietnam is still limited to scientific reports and articles.With geothermal power that can operate continuously around the clock, regardless of weather factors, the infinite underground energy source will be very useful to the Northwest. Because the characteristics of all localities in the region often need drying to preserve agricultural products due to the lack of sunlight in the winter harvest season, post-harvest storage depends mainly on weather and craftsmanship. high wastage rate. On the other hand, the Northern mountainous provinces are facing a serious shortage of electricity. The construction of small hydroelectricity in the northern mountainous provinces has been evaluated as "broken in battle", bringing into full play, such as rivers from Ha Giang which sometimes have to carry 3-6 hydroelectricity. From the research results, the team recommends using binary technology to exploit geothermal resources in the Northwest. The essence of this technology consists of two cycles: The first cycle uses hot water directly from the geothermal solution pumped and passed through the heat exchanger system, the heat of the hot water will make the exchange The steam at 80 degrees Celsius creates pressure to rotate the turbine. After passing through the turbine, this steam is condensed into a liquid solution and returned to the heat exchanger. The second cycle is that after the hot water is pumped and sucked through the power plant system, it will be returned to the tank in a borehole. This technology is also commonly used for geothermal sources with middle temperature. Thus, this technology ensures the exploitation of energy from the source. Geothermal has a low source temperature, but at the same time protects the environment by not releasing hot water.

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