PERSPECTIVES OF GEOTHERMAL POWER USE IN AZERBAIJAN

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ABSTRACT

In paper perspectiv sources of geothermal waters of Azerbaijan and expediency of their use for power generation are discussed. The estimations demonstrate, that the total power recieved from all most known geothermal waters of republic, can be a minimum 700 MW.

Keywords: geothermal waters, power, geothermal energy.

I. INTRODUCTION

Geothermal energy is a proven resource for direct heat and power generation. In over 30 countries geothermal resources provide directly used heat capacity of 12,000 MW and electric power generation capacity of over 8,000 MW. It meets a significant portion of the electrical power demand in several developing countries. For example, in the Philippines geothermal provides 27% of that country's total electrical generation, from power plant complexes as large as 700 MW [1,2,3].

Individual geothermal power plants can be as small as 100 kW or as large as 100 MW depending on the energy resource and power demand. The technology is suitable for rural electrification and mini-grid applications in addition to national grid applications. Direct use of geothermal heat can boost agricultural and aqua-culture production in colder climates and supply heat for industrial processes that can add value to local primary products. Geothermal resources may be especially important and significant in developing nations where no indigeneous fossil fuel resources exist such as oil, coal or natural gas.

Costs of geothermal electric power are very dependent on the character of the resource and project size. The unit costs of power currently range from 2.5 to over 10 US cents/kWh while steams costs may be as low as USD3.5 /tonne. Major factors affecting cost are the depth and temperature of the resource, well productivity, environmental compliance, project infrastructure and economic factors such as the scale of development, and project financing costs.

Geothermal heat that flows from the Earth's hot interior due to crustal plate movements, zones of high heat flow may be located close to the surface where convective circulation plays a signifcant role in bringing the heat close to the surface (see fig.1). Deep circulation of groundwater along fracture zones will bring heat to shallower levels, collecting the heatflow from a broad area and concentrating it into shallow reservoirs or discharging as hot springs. These reservoirs may contain hot water and/or stream. By drilling into these reservoirs, the hot water and/or steam is piped to the surface where it is used for direct use applications, or the high pressure steam is separated to drive turbines for power generation. The low energy waste water form such power generaiton is then usually re-injected back into the reservoir, or further utilised for direct heat applications. This technology enables it to be utilised to generate electricity and provide domestic and industrial heat. Geothermal energy has proved to be reliable, economic, environmentally friendly and renewable.

In general there are two main categories, the high temperature resources and the moderate/low temperature resources. The high temperature geothermal resources (> 200^{o}C) are predominantly found in volcanic regions and island chains. The moderate to low temperature resources are found on all continents. The high temperature is almost always used for power production while most of the low temperature resources are used for direct heating purposes or agriculture and aquaculture.

Lower temperature geothermal resources are found in many regions of the World. They can provide useful energy for heating buildings and agricultural and industrial processes. Such heat can also be available as a by-product of geothermal power generation projects that use higher temperature resources.

High temperature geothermal reservoirs containing water and/or steam can provide steam to directly drive steam turbines and electrical generation plant. Binary cycle sytems using heat transfer media of lower boiling point than water (such as organic fluids), enable power to be generated from lower temperature resources. With over 8000 MW of installed capacity, geothermal electric power generation is a well-proven technology that has been especially successful in countries and islands that have a high reliance on imported fossil fuels.

Power plants as small as 100kW, but commonly 1-5MW, may provide distributed generation on larger grids or they may be a major generation source for smaller power grids. There is a perception that geothermal power plants are base load stations that operate 24 hours a day and 365 days a year. This is not necessarily the case. Indeed geothermal power plants can be designed to follow load demand if necessary such as may be required in mini-grid applications. Small power plants are usually built using a modular approach that reduces site construction costs and can be placed adjacent to the wells so that the overall project has a minimal environmental impact. A summary of typical current costs are provided in the following table 1.

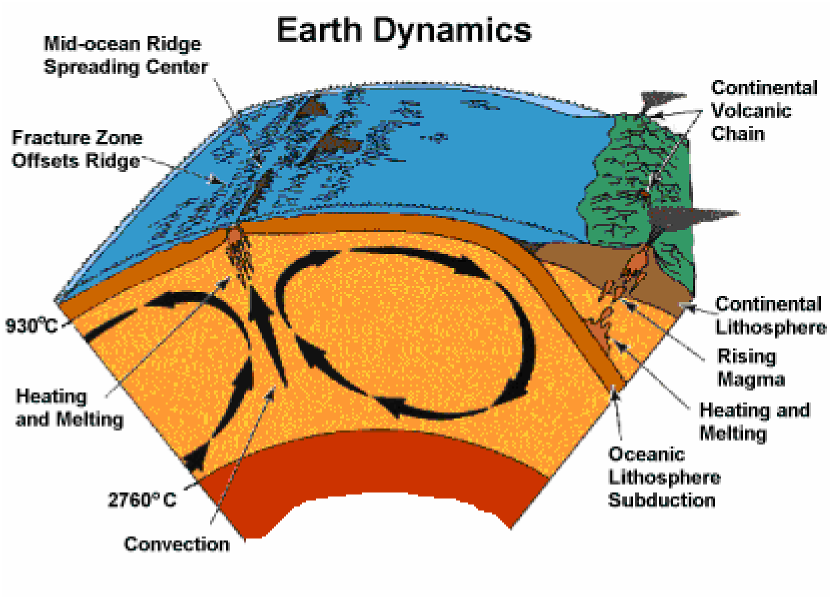

Fig.1. Earth dynamics picture.

Table 1.
A summary of typical current costs of geothermal power

	Cost (USD/tonne of steam)	Cost (USD/tonne of hot water)
High temperature (>150°C)	3.5-6.0	
Medium Temperature (100-150°C)	3.0-4.5	0.2 – 0.4
Low Temperature (<100°C)		0.1-0.2

Utility-scale geothermal power production employs three main technologies. These are known as dry steam, flash steam and binary cycle systems. The technology employed depends on the temperature and pressure of the geothermal reservoir. Unlike solar, wind, and hydro-based renewable power, geothermal power plant operation is independent of fluctuations in daily and seasonal weather.

Dry steam. Dry steam power plants use very hot (>200 °C) steam and little water from the geothermal reservoir. The steam goes directly through a pipe to a turbine to spin a generator that produces electricity.

Flash steam. Flash steam power plants use hot water (>180 ºC) from the geothermal reservoir. When the water is pumped to the generator, it is released from the pressure of the deep reservoir. The sudden drop in pressure causes some of the water to vaporize to steam, which spins a turbine to generate electricity. Both dry steam and flash steam power plants emit small amounts of carbon dioxide, nitric oxide, and sulfur, but generally 50 times less than traditional fossil-fuel power plants. Hot water not flashed into steam is returned to the geothermal reservoir through injection wells.

Binary-cycle. Binary-cycle power plants use moderate-temperature water (107ºC–180ºC) from the geothermal reservoir. In binary systems, hot geothermal fluids are passed through one side of a heat exchanger to heat a working fluid in a separate adjacent pipe. The working fluid, usually an organic compound with a low boiling point such as Iso-butane or Iso-pentane, is vaporized and passed through a turbine to generate electricity. An ammonia-water working fluid is also used in what is known as the Kalina Cycle. Makers claim that the Kalina Cycle system boosts geothermal plant efficiency by 20–40% and reduces plant construction costs by 20–30%, thereby lowering the cost of geothermal power generation.

The advantages of binary cycle systems are that the working fluid boils at a lower temperature than water does, so electricity can be generated from reservoirs with lower temperature, and the binary cycle system is self-contained and therefore, produces virtually no emissions. For these reasons, some geothermal experts believe binary cycle systems could be the dominant geothermal power plants of the future. A schematic of a typical binary cycle power plant is shown in fig.2.

As of 2000, approximately 8,000 megawatts (MW) of geothermal electrical generating capacity was present in more than 20 countries, led by the United States, Philippines, Italy, Mexico, and Indonesia (see Table 2). This represents 0.25% of worldwide installed electrical generation capacity (see Fig..3).

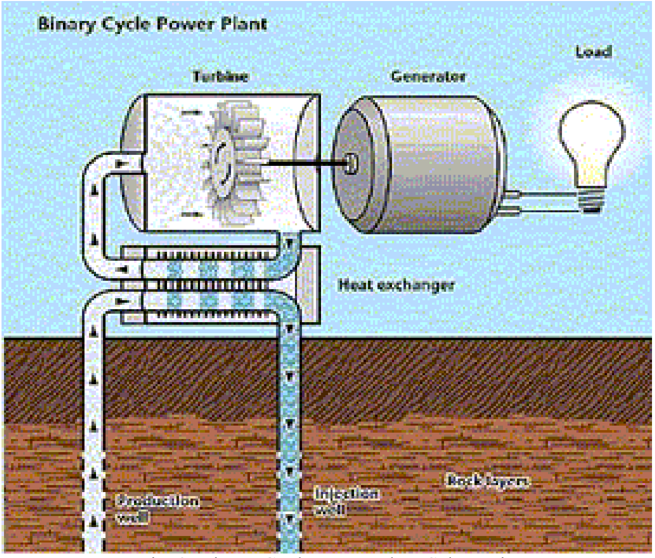

Fig. 2. Binary Cycle Power Plant Schematic
Source: National Renewable Energy Laboratory (NREL)

Table 2.
Installed Geothermal Generating Capacities Worldwide

Country	1995 (MWe)	2000 (MWe)	Country	1995 (MW)	2000 (MW)
United States	2,817	2,228	*Kenya*	45	45
Philippines	1,227	1,909	*Guatemala*	33	33
Italy	632	785	*China*	29	29
Mexico	753	755	*Russia*	11	23
Indonesia	310	590	*Turkey*	20	20
Japan	414	547	*Portugal*	5	16
New Zealand	286	437	*Ethiopia*	0	8
Iceland	50	170	*France*	4	4
El Salvador	105	161	*Thailand*	0.3	0.3
Costa Rica	55	142	*Australia*	0.2	0.2
Nicaragua	70	70	*Argentina*	0.7	0
Total (MW)				**6,833**	**7,974**

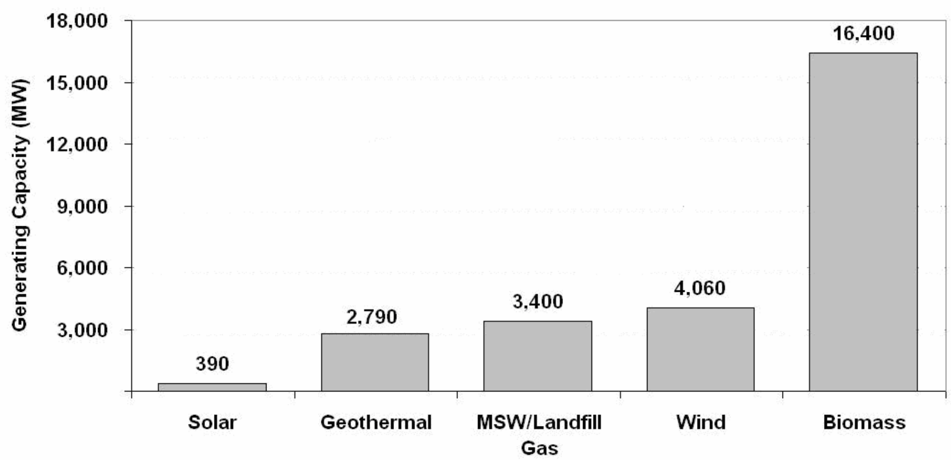

Fig.3 Installed Some Renewable Generating Capacities Worldwide.

II. MAIN TEXT

As is known, the Azerbaijan Republic is rich with the thermal waters had mainly in regions of Bolshoy and Maliy Caucasus, Apsheron and Talish areas. On Maliy Caucasus thermal sources are grouped in region of the Terter and Arpachay rivers. The geothermic step for sources is 2-3 m/°C. In region Bagirsaga on depth of 100 m the temperature of water is equal 80°C, region Istisu on depth of 60-70 m the temperature of water is equal 62°C, on depth of 300-350 m the temperature of water is equal 75°C. The total discharge of water in region Verhniy Istisu is.800-900 m^3/day, in region Nijniy Istisu discharge is 25 m^3/day. In Nahchyvan regions in sources of Sirabski, Nagadjirski and Djulfinski mineral water a long-hole drilling it is possible to bring out a heat water.

In Daridag region driven wells are drilled on depth up to 665 m and water with temperature 41-52°C and a discharge 1080-2850 m^3/day is gained. Thermal waters in Masalli, Lenkoran and Astara regions are interlinked to the traversing Talish Mountain regional fracture. In Arkevan region (Masalli) sources thermal waters with temperature 44-45°C on the surface have been open by driven wells depth up to 500 m. The temperature of water in various sources varies from 50 up to 64°C. A discharge of driven wells is 860-1300m^3/day. In Lenkoran region (Meshasu, Ibadsu, Gavzavua and Gavtoni) a series of driven wells by depth of 465-1000 m is drilled and have got water with temperature up to 50°C. Temperature of water in sources is 30-43°C, a discharge is 2260 m^3/day. Temperature of water in driven wells on surface is 23-39°C, a discharge is up to 4000m^3/day.

In area of sources in Astara region thermal waters with temperature 35-50°C are opened by driven wells of depth of 30-500 m. The total discharge only of 7 sources in Talish with temperature 45-64°C is 6272,8 m^3/day. If to utilize heat of these waters, cooling them only on 20°C, the thermal power wills approximately 6 MW. On South and North-East inclines of Bolshoy Caucasus outputs of term testify to wide evolution of thermal waters. In Gah region fields of thermal waters relate to such sections. In Gabala region there are Ilisy with temperature of sources up to 40°C and Kurmuk with temperature up to 30,5°C. In Oguz region there are Bum sources with temperature 39,4°C. In Shamaha region there are Xalxal sources with temperature 32°C. The hydrotherms, capable to flow out on a surface in the form of hot wells, exist in Ilisu, Gonaxkend, on Kurmuxchay, in Gah region, Xaldan, Shamaha.

In Prikaspiy-Guba zone (a South-East incline of Bolshoy Caucasus) thermal waters were opened by 8 drilling with a total discharge 20470 m^3/day and with temperature 50-84°C [3]. The total power (under condition of increasing temperature of water only on 20°C) is approximately 20 MW. In Xachmas region by one borehole thermal waters were opened at discharge of 1228 m^3/day. and with temperature 58°C. In Yalama section by one driven well thermal waters were opened at discharge of 500 m^3/day., with temperature 95°C. The minimum thermal power of these drilling is accordingly 1,2 and 0,5 MW.

On Apsheron thermal waters are find out by driven wells on the various depths. In peninsular part of Apsheron, to the east of Govsan village, the temperature of mineralized water from drilled depths is 100-135°C. On Bibi-Eybat, nearby at Baku, chloride-sodium bicarbonate waters gush with temperature 71°C and a discharge more than 450 m^3/day. In Guzdel by driven wells water with temperature more 50-65°C is extracted. Hot waters are overflowed also from driven wells in the Kara-Eybat on island Chilov and in other places. It is necessary to note, that with depth the temperature of thermal waters is increased.

The Kura trough is the uniform, difficultly ready-built artesian basin with the composite allocation of temperature and a composition of water. Thermal waters occur here on depths from 200 up to 4500 m. Within the bounds of the Kura troughs waters coordinated to Apsheron sedimentation, are pressure-tight and self-flowing out, a chloride-sodium bicarbonate composition. Thermal waters are opened by many driven wells drilled on oil and gas on areas of Babazanan, Neftchala, Hilli, Mishovdag. These waters are concentrated by iodine and a bromine.

In 1969 on area of Jarli (Kyurdamir region) thermal waters at rate of 20000 m^3/day and temperature up to 100°C had been opened by the driven well in top cretaceous sedimentation. At cooling up to 40°C the thermal power of this driven well will 53,5 MW. In Kyurdamir region by one driven well thermal waters were opened at discharge of 10000 m^3/day and with temperature on a mouth 82°C. The thermal power (at cooling up to 40°C) is 20,4 MW. On Shirvanli area by one driven well thermal waters were opened at discharge of 3000 m^3/day and temperature of 60°C. On the basis of the carried out prospecting it is determined, that South-West bort side of Kure trough has enough resources of thermal waters which one it is possible is effective and complexly to use with the purposes of a heating [3].

On the area of the Bard nearby driven wells of depth of 1500-1600 m from Sarmat sedimentation thermal waters are situated at discharge of up to 1500 m^3/day and temperature of 45°C. Thermal waters with analogous parameters also are opened by driven wells on areas Sorsor, Karajalli, Beylagan, Sovetlyar etc.

In table 3 calculated by K.M.Aliev and his colleagues prospective operation reserves of thermal waters on republic are shown. As a result of the assaying of the collected materials a series of regularities of thermal waters allocation are determine. On its basis in 1982 the hydrogeothermic map for territory of Azerbaijan was made up [3,4,5].

III. CONCLUSION

Thus, the geothermic regime in the viewed areas varies under the summary effect of many factors influencing a heat flux density. The determined abnormalities of a geothermic regime can be explained by a lithological composition of mucks, the tectonic phenomena (structures, fractures), proximity quaternary and mud volcanoes, and also dynamism of waters.

Geothermal sources of Azerbaijan are low-temperature. Despite of it, development and use of geothermic sources in Azerbaijan is very perspective. For today, cooling thermal waters on 20-40^{o}C it is possible to receive totally from all sources specified in table 3, minimum 700 MW.

Table 3.
Prospective production reserves of thermal waters in Azerbaijan Republic

Hydro-geological sections	**Temperature of water, °C**	**Prospective Reserves m^3/day**	**Minimum of received power, MW**
Mountain-folded zones of Bolshoy Caucasus	30-50	2 000	5
Kusar submontane lowlands	30-97	21 654	70
Apsheron	20-90	20 000	65
Mountain-folded zones of Maliy Caucasus	30-74	4 171	15
Autonomous Nahchyvan republic	40-53	3 000	10
Mountain-folded zones of Talish	31-43	14 405	40
Lenkoran lowland	42-64	7 908	15
Kura trough	22-95	172 466	480
Summary in Azerbaijan		245 604	700

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