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Screening Criteria Required for Conversion of Abandoned Oil and Gas Wells into Geothermal Wells

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Abstract: ***In the modern world all the sectors one way or the other depend on electricity which is most likely generated from hydrocarbons. To extract hydrocarbons i.e. oil and gas we require a passage (borehole) from the reservoir (located beneath the surface) to the surface. This is the reason we are drilling no of wells to extract the oil and gas. Once the reservoir is depleted the wells are abandoned. The life time of an oil well is approximately 20 years till date there are many wells that are abandoned. To meet the energy demand which is increasing rapidly we can utilize the abandoned wells to generate electricity using geothermal energy. For this purpose we can inject water in these abandoned wells to extract the heat from the reservoir to the surface in the form of steam which can be used for generation of electricity. Water injected into the well bore is converted in to steam after extracting the heat from the reservoir the steam should be maintained at a temperature of 108-182 °C when it reaches the surface this for this purpose we require and an oil and gas wells with moderate depth and high geothermal gradient. In this paper we have prepared the screening criteria which can be used for converting abandoned oil and gas wells into geothermal wells.***

Keywords: geothermal wells, oil and gas wells, Electricity

I. INTODUCTION

In the present world were technology is embedded into human life electricity is required to run gadgets and other electrical equipment's that are used in day to day life. So, electricity plays a crucial role in present times. Electricity is produced from various sources like Coal, Natural gas, Hydro power, Nuclear energy, oil and other renewable energy resources. Hydrocarbons contribution is high in electricity production. After extracting hydrocarbons from the subsurface the wells are abandoned. These wells can be used to extract geothermal energy.

The word geothermal originates from Greek roots where geo means earth and thermal means heat. Geothermal energy originates from the natural formation of the planet and the radioactive decay of materials. The geothermal gradient can be defined as the difference between the temperature from the core of the earth and its surface. So as we go deeper into the earths formation the temperature increases. That is due to the heat transfer from the inner core to the outer core via conduction and heat transfer from outer core to upper and lower mantle through convection .which intern heats the crust. The temperature at the inner core is approximately 4300 °C. Thus the heat transfer and radioactive decay of elements causes the crust to get heated up. This makes Rock and water in the crust heated up to 370°c.The Earth's internal thermal energy flows to the surface by conduction at a rate of 44.2 terawatts (TW), and is replenished by radioactive decay of minerals at a rate of 30 TW. This energy can be utilized efficiently by converting heat into electricity. For this purpose we can convert the abandoned oil and gas wells in to geo thermal wells which will be economically viable than drilling a new geothermal well alone.

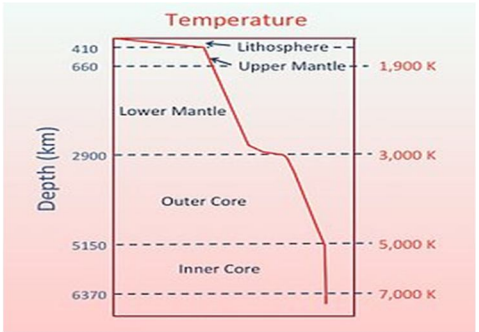


Fig. 1. Earths Internal Temperature

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II. TYPES OF GEOTHERMAL WELLS

Geothermal wells generally are of three types, although their main function is to turn large turbines which run electrical generators. The type of geothermal wells which can be employed mainly depends on the steam and its temperature after reaching the surface. The types of geothermal wells are as follows

A. Direct Dry Steam Wells

Steam plants generally use hydrothermal fluids that are basically steam. The process is simple which allows the heated steam to directly run the turbine, which drives a generator that produces electricity. The steam eliminates the need to burn any hydrocarbons or fossil fuels thus eliminating the emission of greenhouse gases, and the need of transport and store of fuels. This is the oldest type of geothermal power plant it was first used at landrail in Italy in 1904. Dry steam technology is currently used at the geysers in northern California, while the plant emits only excess steam and very minor amount of gases.

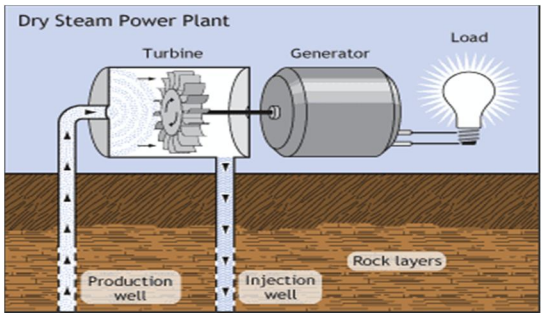


Fig. 2.Dry steam wells

B. Flash And Double Flash Cycle Wells

This technique is same as the direct dry steam wells the only additional part comes with the introduction of a flash tank which helps in generating electricity more efficiently. Hydrothermal fluids with temperature above 182 °C can be used in flash plants to generate electricity. The fluid stream after reaching the surface must be above 182 °C. The stream is allowed to flow through a flash tank which is held at a much lower pressure than the fluid causing some fluid to rapidly vaporize or flash which drives the turbine. If any fluid remains in the tank it can be flashed again in a second tank or double flash to extract more energy.

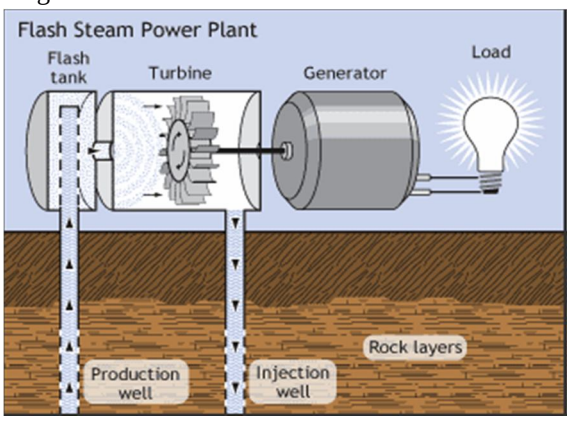


Fig. 3. Flash cycle

C. Binary cycle wells

Most geothermal areas have moderate temperature that is below 204 °C. Generally streams with temperature less than 182 °C can be considered which means that the if stream after reaching the surface is below 182 °C the steam must be pumped out of the well and passed through a heat exchanger where second working fluid or binary fluid mainly pentane. Butane, isopentane is pumped through the heat exchanger at pressure of 500 psi where the heat is exchanged between steam and binary fluid which gets vaporized and then directed through a turbine. The vapor the exiting is condensed by radiators or cool water and cycled back through heat exchangers. The water from the heat exchangers is again pumped to the injection well which and send to the reservoir. The process is cyclic and ecofriendly with less emissions and water wastage.

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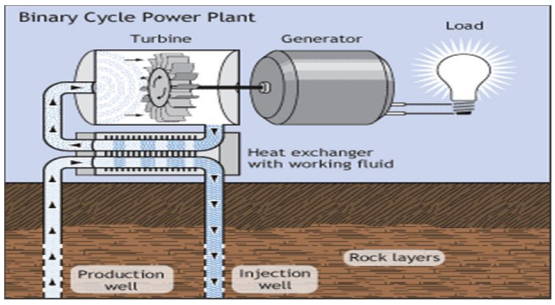


Fig. 4. Binary plant

III. ENHANCED GEOTHERMAL SYSTEMS

EGS is the most common system which can be used for abandoned oil and gas wells. This technique was adapted from oil and gas extraction techniques. Wherein the water from the condenser is re-injected into the well thereafter the water passes through the reservoir causing the water to heat up, the water then converts into steam at higher temperature again the steam produced flows through the well bore (via the insulated pipes) which after certain heat losses is allowed to rotate the turbines resulting in electricity generation. There are several advantages of EGS that is if the water is not present in the form of aquifers, then the condensed water can be re-injected into the well; this process is cyclic so water wastage is minimized causing less environmental impacts. The water is injected specially through the injection wells, and the injected water is injected with certain pressure such that when it flows through the reservoir it causes fractures thus increasing the permeability, allowing the water to flow easily and heats up to produce steam. The fracturing in this system is a bit different from hydro fracturing (in oil and gas) because (EGS) only requires water with certain pressure which causes the reservoir to fracture; proppants are not used in this process. Moreover EGS helps generating adequate amount of steam with negligible environmental impacts.

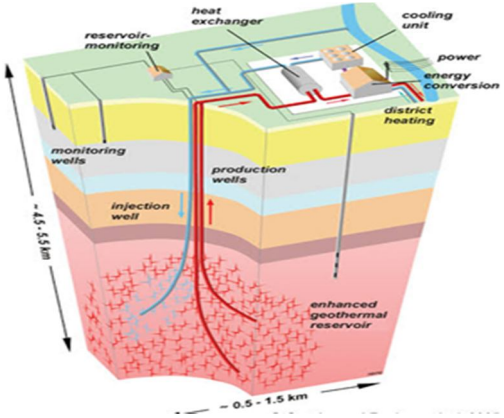


Fig.5.Enhanced geothermal systems

IV. SCREENING CRITERIA FOR CONVERSION OF ABANDONED OIL AND GAS WELLS INTO GEOTHERMAL WELLS

To evaluate the screening criteria for conversion of abandoned oil and gas wells into geothermal wells the first and foremost thing which has to be considered is the geothermal gradient, and the reservoir should have the geothermal characteristics to generate steam. There are also several other screening parameters which are to be considered. Proper evaluation of all these criteria will lead to a successful conversion and thus helping the wells to contribute in the renewable energy sector. The screening criteria for conversion of oil and gas wells into geothermal wells are as follows.

A. Geothermal Gradient And Depth

Geothermal gradient and depth also plays a vital role because these are the parameters which helps in high temperature steam generation because both depth and geothermal gradient is directly proportional to temperature that is temperature increases as depth and geothermal gradient increases. The only drawback with deeper wells (that is more than 6 kms) is that it causes heat losses and additional techniques and equipment's resulting in increase in capital. Following data is the average geothermal gradient in India correlated with the depth

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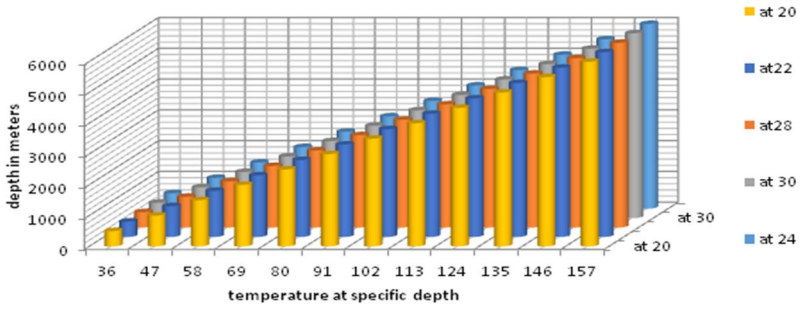


Fig. 6. Temperature vs depth graph

B. Depth

The depth is also considered to be important criteria because more the depth of the well more is the temperature and more efficiently the steam is released with less heat loss. That means if the geothermal gradient is more with less depths the well is of no use. The main criteria is that the wells with both high depth and geothermal gradient should be selected .wherein more depth wells ranging from 3 to 10 kms are considered to be thebest source. But the problem with more depths is the pressure required to pump the water into the injection well will be more. Deep wells are seen in oil and gas industry these days wherein the average depth of oil and gas wells are more than 3 kms. The only drawback with deeper wells that is more than 6 kms which causes heat losses and additional techniques and equipment's resulting in increase in capital. Wells with directional drilling can also be considered. The most concern is in the wells with aquifers at shallow depths. If aquifer is present near to the well bore shallow depths it may cause condensation of fluid resulting in less steam generation. This is due to the cool aquifers, which will act as coolant to the steam produced causing condensation of steam and evolving less heat loss apart from aquifers, the hot stream flowing through the well bore may undergo heat exchange with the well bore resulting in heat losses from the hot stream the heat losses are severe in high depths, however it can be controlled using proper insulation. Moreover, appropriate depth and geothermal gradient must be evaluated such that the steam reaching the surface must range from 108°c to 182°c. In addition to this if the temperature is in this range then binary system must be implemented to make the complete use of the steam with the help of heat exchanger.

C. Thermal Conductivity Of Reservoir

Thermal conductivity of reservoir should be high for effective heating of injected water. The thermal conductivity causes water to heat up and produce steam. Different reservoir rocks have varying thermal conductivity for example in oil and gas the major reservoir rocks found are either sandstone or carbonate where sandstone has the highest thermal conductivity among the reservoir rocks thus abandoned oil and gas wells whose reservoir rock is sandstone has a higher thermal conductivity causing the water to get heated up more effectively. And more than 60 % of the reserves found in the world are sandstone reservoirs thus making oil and gas wells more favourable for conversion into geothermal wells.

D. Insulation

There are different kinds of insulators used to minimize heat losses when the steam flows in the pipe from the reservoir to the well bore. Each insulator has its own significance the most efficient and cost effective the insulators can be used to maintain the temperature above 108°c the need for insulation is to lower the heat transfer in the well bore from the fluid to the formation. Insulators used should have low thermal conductivity and lower heat transfer coefficient the types of insulators which can be used are provided below

Table 1. Types of insulators

Sno	Insulators	Thermal conductivity
1.	Vacuum insulated tubing	0.012W/m*K, to 0.04
2.	Cellulose	0.040 W/m*K.
3.	Fiber Glass	0.035 to 0.04 w/m*k
4.	Vikotherm rubber based	0.013 to 0.019 W/m*K.

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The most efficient and effective insulator is vacuum insulated tubing because it can be used for depths up to 3600 meters and can also withstand temperatures up to 370°c. Although it is expensive but it effectively minimizes the heat transfer between the bore hole and the pipe.

V. CONCLUSION

In this project we came across many parameters which help converting the abandoned oil and gas wells into geothermal wells. But the aim is to convert oil and gas wells into geothermal wells is because drilling any well incurs huge investments millions of dollars even after getting oil and gas from the wells company can attain profits but due to the negative impacts of the industry it is always criticized for pollution and other environmental factors, though life without it is impossible. The research is a proof that it also contributes as a renewable energy with very less or no environmental impacts thus contributing to the renewable energy sector. The abandoned wells which cannot produce or are not feasible to produce or dry wells now have potential for contribution to the renewable energy sector. In order to make it suitable there are certain parameters that has to be considered. The most common type of the system that is the EGS system can be applied for conversion because this system is similar to the function of oil and gas wells where the steam produced is condensed after it passes through the turbines and the condensed water is re injected into the well where it again gets heated up and converts into steam this process is cyclic because water produced in the form of steam is again re injected resulting in less wastage of water.

The injected water is injected through the injection well with certain pressure which helps in increasing the permeability of the reservoir by causing fractures in the reservoir. This helps in fracking of the formation thus resulting in more efficient steam production. There are several other advantages which lead the EGS to be the best source of renewable energy. We conclude by saying that this is the only best method for utilizing the ultimate use of the abandoned wells, which will contribute in more electricity generation and space heating in an efficient and eco-friendly manner.

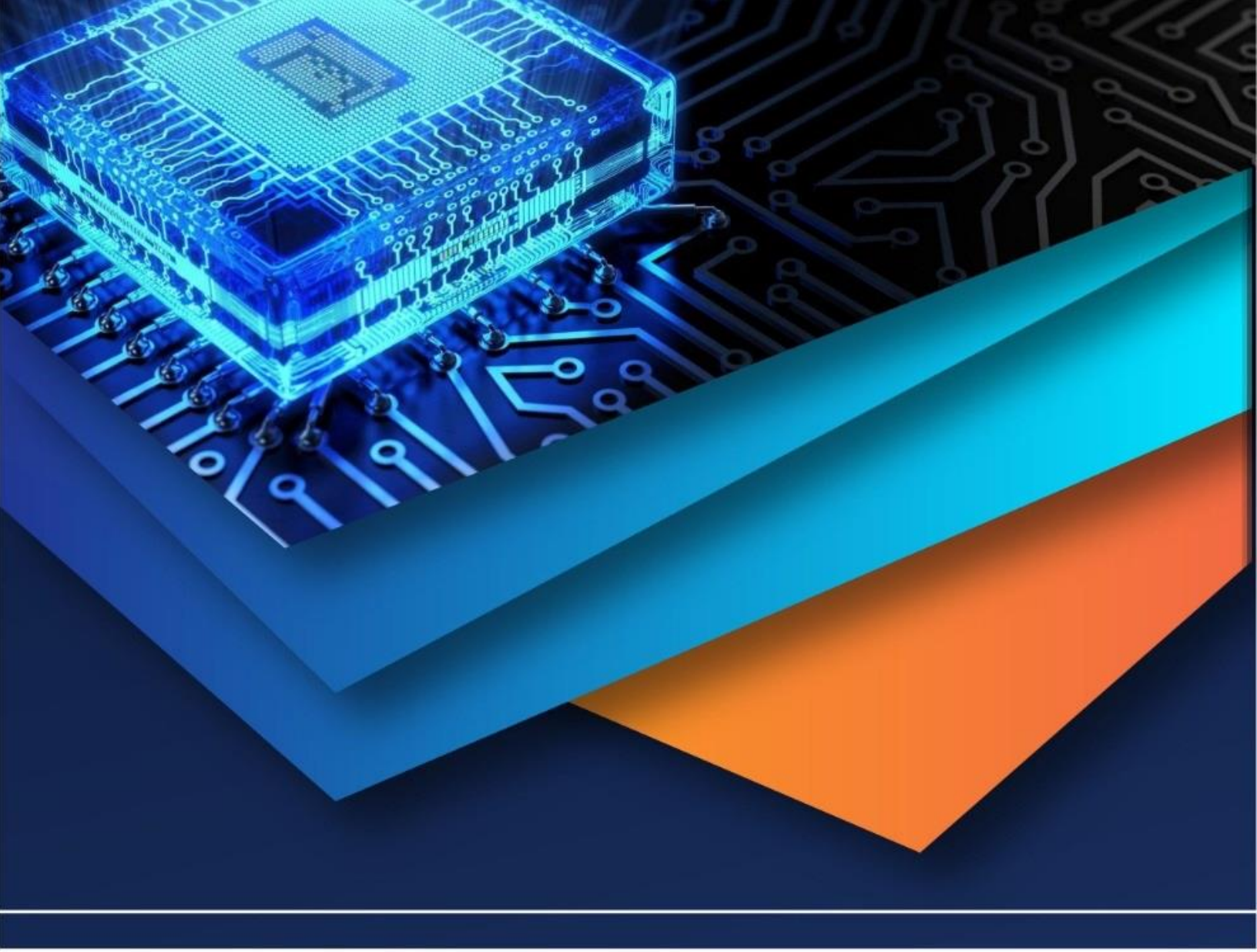
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