Geothermal Energy for Power Generation

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Abstract -- In this paper we will be overlooking one of the renewable source of energy i.e. geothermal energy. It is the fourth largest consumed renewable source of energy after Solar, Thermal and Wind. In this paper we shall be discussing about the harnessing of geothermal energy along with its power generation plants, reservoirs, extraction and uses, new techniques to reduce the plant cost, advantages and disadvantages of this source of energy, and foremost important its future scope. Geothermal energy is abundant and is environment friendly which makes it a sustainable source of energy.

Indexed Terms: Geothermal plant, Reservoirs, harnessing, extraction, sustainable.

I. INTRODUCTION

Geothermal energy can be defined as heat that originates within the earth. This heat occurs from a combination of two sources: the original heat produced from the formation of the earth by gravitational collapse and the heat produced by the radioactive decay of various isotopes.

Geothermal resources can be divided into four types:

1. Hydrothermal
2. Geo-pressured
3. Hot dry rock, and
4. Magma

II. GEOTHERMAL RESERVOIRS

Reservoirs can be suspected in the areas where we can find:

- Geyser
- Boiling mud pot
- Volcano
- Hot springs

The rising hot water & steam is trapped in permeable & porous rocks to form a geothermal reservoir.

Reservoirs can be discovered by:

- Testing the soil.
- Analyzing underground
- Temperature.

2. Extraction and Uses

The heat energy can be brought to earth's surface by following ways:

- Directly from hot springs/geysers.
- Geothermal heat pumps.

Uses are broadly classifies as:

- Direct use(hot springs, used as spas, drying crops, provide heat to buildings and industrial processes, heating water at fish farms)
- Indirect use(electricity generation)

III. ELECTRICITY GENERATION

There are two types of power plants:

- Flash steam power plant
- Binary cycle power plant

Geothermal plants are often located in areas of high scenic value, where the appearance of the plant is important.

Fortunately, geothermal power plants take up little land space, and, with careful design, they can easily blend into the surrounding environment. Wet cooling towers at plants can produce plumes of water vapor, which some people find unsightly. In such cases, air-cooled condensers can be used. A good example of an aesthetic geothermal power plant is the 35-MW binary-cycle plant located near the Mammoth Lakes ski area in northern California. The plantuses air cooling, has a low profile, is painted in colors that match the natural landscape, and is surrounded by trees.

In flash steam power plants-

- Extremely hot water is rapidly depressurized into steam.
- It is then used to drive the turbine.

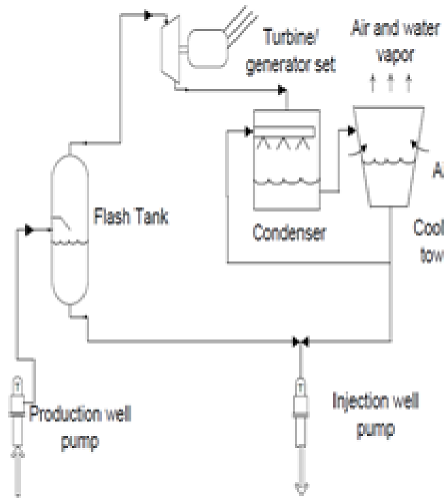

Fig. 1: Example flash-steam geothermal power plant.

In binary cycle power plant-

- Hot water is passed through heat exchanger.
- It heats a second liquid, iso-butane, in a closed loop.
- The iso-butane boils at a lower temp and its steam runs the turbine.

These plants tend to have higher equipment costs than flash plants. Because they transfer heat from the geothermal fluid and return all the geothermal fluid to the ground, they do not have condensed steam available as cooling water. Thus, they must use a separate water source or air-cooled condensers.

Because all of the geothermal fluid is returned to the reservoir, binary-cycle plants do not require mitigation of gaseous releases and reservoir fluid volume is maintained.

Because larger binary plants are typically comprised of small modules, maintenance can be done on one module at a time, thus minimizing the impact on plant output. A schematic of a typical binary plant is shown in Figure 2.

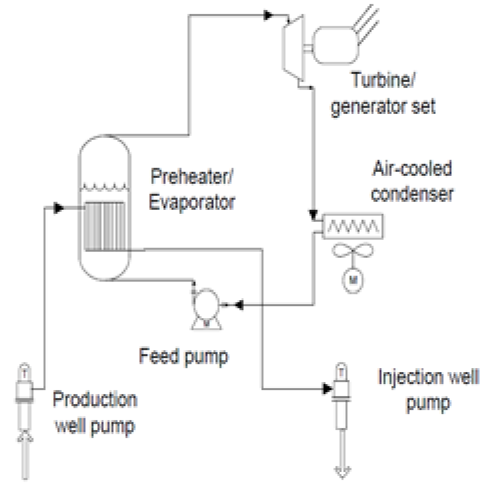

Fig. 2: Example binary-cycle geothermal power plant.

Despite their higher energy costs, small-scale plants offer a number of potential advantages. Skid-mounted units can be built in the factory and shipped anywhere in the world. Because they are modular, a plant owner can start with a small investment and add additional modules later. Small plants can be designed to operate automatically. Their economics can become attractive in regions where low-cost shallow wells are available and where the exit brine from the plant can be used for direct heating applications. Small plants may be especially well suited for mini-grid applications in developing nations where the competition is imported diesel fuel.

IV. GEOTHERMAL GRADIENT

Geothermal Gradient is defined as the rate of increase of temperature with depth. Surface temperature is assumed to be 24°c (75°f) for onshore wells, and 15°c (59°f) for offshore wells. Geothermal gradients were computed on the assumption of a linear increase in temperature with depth. With this assumption, the temperature of any depth can be expressed by the following equation:

$$Tz=t0+tgz/100$$

Where:- T_z = the wellbore temperature (°c) at depth z (m).

T_0 =the mean surface temperature (°c).

T_g =the geothermal gradient in (°c/km).

V. CURRENT RESEARCH ACTIVITIES

The Department of Energy research program is aimed at reducing the Cost of geothermal electricity. This involves research in the following areas:

1. Exploration and Reservoirs

Exploration research focuses on developing more accurate and lower cost means for finding and mapping geothermal resources. In this way the financial risk of developing a project can be minimized. Reservoir research is aimed at maximizing the production rate and lifetime of the geothermal resource.

2. Drilling

The cost of drilling a well can be a significant portion of the overall plant cost. Drilling research has focused on means to reduce the costs of drilling through hard rock in high temperature, corrosive environments. Recent accomplishments include the development of slim hole drilling that reduces costs by up to 50% and improved drilling control and tools.

3. Energy Conversion

Energy conversion research is aimed at reducing the delivered electricity cost by improving performance, lowering equipment cost, and reducing O&M costs of geothermal power plants. Because geothermal power plants operate at relatively low temperatures compared to other power plants, thermodynamics dictates that they reject to the environment as much as 90% of the heat extracted out of the ground. Research has thus focused on improving the heat rejection equipment, and new designs of both water cooled and air-cooled condensers have been developed. Other research accomplishments include improved thermodynamic cycles that extract more energy out of each kilogram of brine, better maintenance techniques, and the development of heat exchanger linings that protect low-cost heat exchanger materials from corrosion and scaling when subjected to geothermal fluids.

VI. ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

- Available all the year around.
- Does not involve any combustion of fuel.
- Independent of weather.
- Clean resource.
- Economically sound alternative.
- Overall, geothermal is a sustainable resource.

DISADVANTAGES:

- Not widespread source of energy.
- High installation cost.
- Can run out of steam.
- May release harmful gases.
- Transportation.

Earthquakes.

VII. CONCLUSION

Geothermal heating system can replace fossil fuel heating system in a particular area. Annual costs for common heating purposes can be reduced by more than 60%. Continued energy shortages have created added interests in geothermal energy for power generation. Potential exists to provide all energy requirements in the US .Geothermal energy appears to be a partial solution to our energy needs.

VIII. FUTURE SCOPE

The future of geothermal energy can pretty much be summed up with a single word: More.

1. Geothermal energy is often considered the third or fourth most important source of renewable energy, behind solar, wind, and hydro.

2. Engineers have also devised and improved 'binary cycle' plants that release no emissions except water vapor.

3. Geothermal is also getting cheaper, as the technology improves.

4. According to the Union of Concerned Scientists, since 1980, the cost of operating geothermal power plants has declined by as much as 50%.

5. In some markets, buying power from geothermal plants will soon be as cheap as it is from its much dirtier fossil fuel counterparts.

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