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Power Generation using Wind and Geothermal Hybrid: A Case Study from Dholera

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ABSTRACT

India is planning to achieve around 50% of clean energy share of 500 GW renewable energy capacity by 2030. In this clean energy drive of India geothermal plays an important role. The geothermal fields of India are categorised into four classes on the basis of its tectonic framework. The present study is based on Dholera geothermal field which is a low-medium enthalpy field of India. In this paper the low enthalpy geothermal water has been used for space heating and cooling purpose and the residual of 80oC from the plant will be used for power generation using wind and geothermal hybrid. A novel hybrid technology is suggested in this paper which combines a ventilation system with a wind turbine to generate power. To obtain the desired air velocity within the column, geothermal energy will be employed as a heating element. This heated wind then will act as the source to drive the wind turbine for power generation. A prefeasibility model for this hybrid wind and geothermal technique has been proposed for electricity production which is first time in India.

1. INTRODUCTION

Natural resources that refill more quickly than they are used up are considered to be sources of renewable energy. Examples of such sources that never run out are the sun, the wind, and the earth. The heat-based energy that comes from deep inside the Earth is known as geothermal energy. Despite being present in the Earth's crust and deeper areas in huge and varied, practically infinite amounts, this heat is unevenly dispersed, seldom concentrated, and frequently found at depths that are too great to be useful for economic purposes. The usage of the hot fluids depends on their temperature and pressure and can be either for the production of electricity or for industrial purposes like space heating. The fluids are retrieved from the reservoir via wells (Barbier, 2002). Research on the issue of technology for power generation is being conducted utilising new low-temperature geothermal resource cycles like ORC and EGS.

The use of wind turbines to produce power is called wind energy. Wind energy is a well-liked, ecologically friendly, renewable energy source as opposed to burning fossil fuels. In the past, wind energy was used to power sails, windmills, and wind pumps. Today, wind energy is mostly utilised to produce electricity. Worldwide investment in wind farms has surged, but there is still room for improvement in terms of cost and efficiency. Wind energy may be harnessed and turned into electrical energy by using a wind energy system. A wind energy system's output power fluctuates in response to wind speed. Due to the nonlinear nature of the wind turbine, it is challenging to maintain it operating at its maximum power output under all wind speed conditions. Studies on techniques for monitoring the wind turbine's peak power have been conducted in great numbers; this procedure is known as MPPT (Maximum Power Point Tracking) control (Soetedjo, et al., 2011).

The research and application of wind energy to fulfil electrical demand has attracted a lot of attention in recent years in response to concerns about the depletion of power sources and raised public awareness of the potential environmental repercussions of traditional energy systems. Innovations in wind generation techniques will keep promoting the use of wind energy in grid-connected and stand-alone systems. A wind energy conversion system converts the available natural energy at the system location into electricity (WECS). When designing a suitable framework for a wind turbine generator, three factors that directly affect the output of the generator must be taken into account (WTG). In order to calculate the power output of a WTG component, the relationship between the power output and the wind speed is then employed (Billinton and Allan, 1996).

Given the rising cost of energy, growing demand for it, and the eventual depletion of fossil fuel supplies, research and development on renewable energies is practical. Renewable energy sources can only be used to the extent that they are effective and widely available.

Efficiency, which is a key component of what makes renewable energy sources affordable and cost-effective, has proved challenging to assess. It has been proposed to combine them in order to boost their effectiveness together with the cutting-edge technology of each renewable energy source. The combining of two renewable energies, geothermal and wind, for power generation is explained by the hybridization process of the two energies.

2. METHODOLOGY

Exergy loss through reinjection is high in the majority of geothermal power stations. The injected waste fluid, which generally has a temperature of approximately 80^{o}C, can be thought of as a total exergy loss if it doesn't contribute to the sustainability of the reservoir, quite apart from the technical problems associated with reservoir management (Jalilinasrabady and Itoi, 2012; Jalilinasrabady et al., 2010). There have been several attempts to create techniques for low temperature resources to produce power. The majority of them have concentrated on ORC cycles. In catastrophe situations, particularly in rural regions, these compact units are typically not very simple and may have maintenance and environmental difficulties. It would be a game-changer for geothermal power generation and would boost its renewability and sustainability if some novel concept could assist in producing energy with these low temperature fields and as a bottoming unit with presently operational plants. The wind turbine concept has been successful, and at this time, wind farms are helping to produce electricity. It appears that there is good potential for producing power using a hybrid system, which is uncomplicated, local, and renewable.

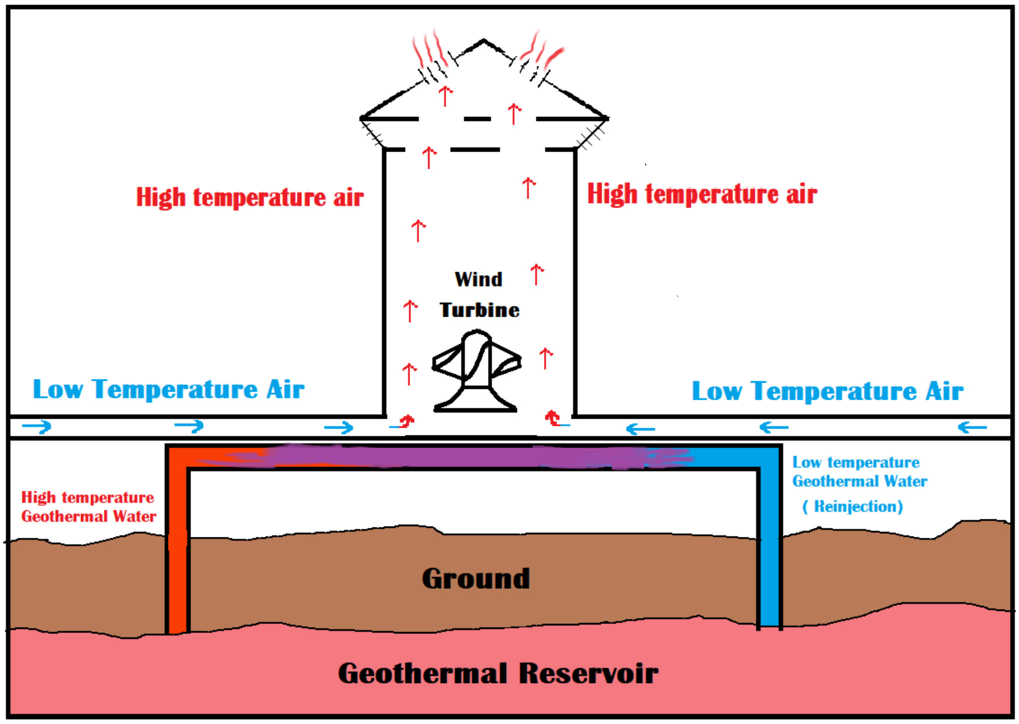

Figure 1: Power Generation using Wind and Geothermal Energy

Figure 1 shows the wind geothermal hybrid system. High-temperature geothermal water is pumped up from a geothermal reservoir. It is brought in indirect contact with the atmospheric air and heat exchange takes place. The air gets hotter and rises up in the chimney. After the heat has been evacuated from it, geothermal water is re-injected in the reservoir. A wind turbine is installed within the chimney, and with the aid of the heated air pressure, the turbine revolves and generate power. The air then is vented out through the top of the chimney.

2.1 Geothermal Heat Supply system

The pond will receive water that has been dumped from a separator or hot spring water that has naturally discharged at a temperature of 60 to 100 C. Since the majority of the pond will be covered by a chimney, the calculated value of heat loss is anticipated to be lower than the heat loss calculation from a swimming pool used to calculate heat loss from the pond. The fluid dynamics and the heat transfer phenomena between the pond and chimney are ignored in this section of the paper, but they must be thoroughly studied for future research.

2.2 Wind Turbine

A wind turbine is an apparatus that transforms wind kinetic energy into electrical energy. For a wind turbine to operate, several requirements need to be met, including wind continuity, and speed. Reduction gearboxes are used to link wind turbines to their generators so they can achieve the 1500 or 3000 rpm generator speed needed. Because they require so little upkeep and care, wind turbines are incredibly reliable.

2.3 Thermal Chimney

One type of ventilation that may be employed in buildings is thermal chimneys. By making use of the ideas of heat transfer and fluid dynamics, it naturally ventilates a building without the need for external energy. Because air density varies with temperature, a thermal chimney makes use of this phenomenon. The use of thermal chimneys for electricity generation using wind turbines, glass roofs, and chimneys is another use. Hot air rises up the chimney because it is lighter than cold air. As a consequence, heated air accelerates the rotation of blades and provides mechanical energy through pressure-staged wind turbines at the foot of chimneys, which is then converted into electrical energy through conventional generating (Bergermann, 2002).

2.4 Heat Losses

The air temperature and wind speed have a significant impact on heat loss owing to convection. Equation 1 demonstrates that the amount of heat lost by convection will grow as wind speed and ambient temperature increase.

$$q_c = h_c (T_w - T_a) \qquad \ldots\ldots (1)$$

3. CONCLUSION

Geothermal and wind energy can be the source of cheap power in many regions. But like most of the renewable energy, they are also constrained by locational and seasonal constraints. It has been suggested in this study, to use a hybrid system of geothermal and wind energy to produce electricity. The concept is at its theoretical stage and requires actual field tests. Which will lead to actual cost benefit analysis and future potential of this technology. The hybrid nature enables the engaged renewable energy sources to strengthen their weaknesses and complement one another. Since each of these renewable energy sources is location-dependent, locations with geothermal potential in practically all categories might profit from this approach. The concept of a hybrid will expand their use. This method of generating electricity can be used in regions like the Middle East and Africa.

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