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Mitigating Limitations of Hydro Power, Geothermal and Biomass Energy

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ABSTRACT:The electricity requirements of the world including India are increasing and the power demand is outdoing power supply. Environment protection also needs equal attention hence renewable resources are seen as a way out. In this paper, procedures and techniques have been proposed to mitigate shortcomings of renewable resources.

KEYWORDS: Hydro power, geothermal energy, biomass, Hydropeaking, PPP, EGS, and PEMFC

I. INTRODUCTION

A. HYDRO POWER

Hydropower is a main source for renewable electricity generation and it serves as an important potential to be marketed as green power. Although renewable sources of energy such as solar and wind are heading very fast towards electricity generation, but hydropower still holds the largest share of the global electricity. In fact, in the 20th century, hydroelectric power was so large that it was called “white coal” for its power and plenty but due to certain claims like availability of water, unlike coal, was highly variable which completely depends on season. So now with time the metaphor of “water as coal” has been diminished. Hydroelectric power proved to be the first and simplest electricity generation technology.

Hydroelectric power is nothing but harnessing energy from flowing water and converting the same into electricity. The water which is used to produce electricity flows from a higher elevation to a lower elevation. A hydropower plant usually utilizes the turbines for changing the motion of water flowing and generators to convert this motion into electricity.

So the question arises that why hydroelectric power is classified as a renewable energy resource and the answer is water. Reason being water vaporizes into clouds and recycles back to the surface of the earth as precipitation. This process is continually recycled and can be utilized to generate electricity over and over. So in simple words hydroelectric power generation is the generation of power from falling water. For the purpose of electricity generation, dams are being constructed on rivers. The running flow of water is then used to move the turbines. The kinetic energy of the moving water is used by the rotating turbines which also cause the magnets of the generator to rotate and to generate electricity. The water is then made to exit through the turbine and is returned to the source of water. So, we can say that running water lightens up everything around.

But as we all know that everything that makes our life easy has some kind of limitations as well. Building of huge dams on the rivers and blocking them can cause serious environmental and social effect because of the following reasons. It alters the normal flow of river, blocks migratory fish passage, can cause sudden occurrence of floods, can increase the number of earthquakes and displacement of local communities. The operation of this plant can potentially harm the environment which include harm to fish populations, a loss of aquatic habitat, a significant change in natural flow regimes and deterioration of the landscape.

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B. Disadvantages and ways to mitigate them:

1. Impact on wildlife

Hydroelectric power generation can have a major impact on aquatic ecosystems. One of the examples is that fishes and other organisms can be injured and killed by rotating turbine blades.

Apart from this, there can also be wildlife impacts both within the reservoirs and in the flowing water. Reservoir water is usually more stagnant than normal river water. As a result, the amounts of sediments and nutrients in the reservoir will be higher than normal, which can result into an excess cultivation of algae and other aquatic weeds. These weeds can leave less space for other river animal and plant-life, and they should be controlled through various means. Since the water is stagnant, so water loss through evaporation in dammed reservoirs will be at much higher rate than in flowing rivers.

Also, if too much water is stored behind the reservoir, segments of the river in the reservoir can dry out. Thus, it become necessary for most of the hydroelectric operators to release a minimum amount of water at certain times of year. If not released appropriately, level of the water will drop resulting to be very harmful for the plants and animals. In addition, the dissolved oxygen is typically low in reservoir water and colder than normal river water. When this water is released, it could have negative impacts on downstream plants and animals. We can overcome these limitations in following manner-

i. To increase dissolved oxygen, aerating turbines can be installed and multi-level water intakes can help to ensure that water which is released from the reservoir comes from all levels of the reservoir, but not just from the bottom
ii. Constructing fish passage facilities.
iii. Modifying dam operations to restore river flows.
iv. Controlling the temperature and oxygen levels of water release from dams.
v. Building fish hatcheries.
vi. Excess of weed can be controlled by manual harvesting or by introducing fish that eat these plants

2. Life-cycle global warming emissions

Global warming emissions are nothing but the production and discharge of gases or radiations that are produced during the installation of hydroelectric power plants, but in recent research it has been suggested that these emissions during its operation can prove to be significantly harmful. The size of the reservoir and the nature of the land that was flooded by the reservoir are the main factors on which the emissions of global warming depend.

Emissions produced by little water storage plants are between 0.01 and 0.03 pounds of carbon dioxide equivalent per kilowatt-hour. Large-scale hydroelectric plants are estimated to produce life-cycle emissions to around 0.06 pounds of carbon dioxide equivalent per kilowatt-hour. However, global warming emissions from hydroelectric plants built in tropical areas or temperate peat lands are estimated to be much higher. Carbon dioxide and methane is released when the vegetation and soil in the area after the flood decomposes. The exact amount of emissions depends greatly on site-specific characteristics. However, current estimates suggest that life-cycle emissions can be over 0.5 pounds of carbon dioxide equivalent per kilowatt-hour.

Estimates of life-cycle global warming emissions for natural gas generated electricity are between 0.6 and 2 pounds of carbon dioxide equivalent per kilowatt-hour and estimates for coal-generated electricity are 1.4 and 3.6 pounds of carbon dioxide equivalent per kilowatt-hour. This can be mitigate by following ways-

i. Mitigation policies can substantially reduce the risks associated with human-induced global warming.
ii. By managing water levels in the reservoir differently but this could affect electricity generations, fishery, and other operations.
iii. Protecting watersheds to reduce erosion into reservoir could also reduce emissions.
iv. By not building them in the tropics as dams near the equator give off much more CO_2 due to anaerobic decay of vegetation than dams further north.

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3. Hydropeaking

Hydropeaking is a practice used to increase river flows from hydroelectric dams during periods of peak demand by electricity consumers. Organisms which are vulnerable to hydropeaking are aquatic insects, vital strands of the river food web, which lay their eggs near shorelines. In Hydropeaking, fluctuating in the daily pattern of water flows occur that can severely have impact on the shoreline habitats because of repeated wetting and drying. When meeting base load requirements, a power station usually discharges a constant flow all day, weeks and even months depending on the scale of the generation needs. When meeting peak load requirements, a power station is turned on at a particular time during the day, generates power at a constant load for a certain number of hours, and is then turned off or set to a different load for another time period, resulting in a high variability in flow discharges. It increases seepage-induced erosion of riverbanks due to frequent water level drawdown. Hydropower stations can also operate in frequency mode, where on or off are brought by generators which depends on the change in electricity demand throughout the day. Following are the measures to overcome this limitation-

i. Ensure 24-48 hour shutdowns on approximately a weekly basis to reduce stresses of water logging and inundation.
ii. Minimizing the duration of maximum discharges to reduce the extent of bank saturation.
iii. Instigating low flow rates for three summer months every year to allow riparian plants to grow and reproduce.
iv. Measures that would improve physical stability of the riverbanks.

II.GEOTHERMAL ENERGY

A. Introduction

Breaking down the word geothermal, 'geo' means earth and 'therm' means heat that is heat from the earth. Heat present at the centre of the earth conducts outwards and heats up the outer layers of rock also known as the mantle. When these melts and becomes molten it is called magma. Magma can reach just below the earth’s surface. When rain water seeps down through geological fault lines and cracks, it becomes super-heated by the hot rocks below. This water comes to the surface in form of hot springs or geysers. At times the hot water becomes trapped below the surface as a geothermal reservoir.

Predictably, there are numerous challenges we face to get the best of this resource. These include high initial cost along with low capacity factor, technological barriers in drilling and exploration processes, environment problems and combination of heat and water available only at specific sites.

B. Disadvantages and ways to mitigate them:

1. Economics

Geothermal industries growth predominantly depends on the government policies and subsidies it is providing as initial setup cost is high which is also not risk free hence there is next to no motivation for private players to invest in this resource. However, maintenance and operating cost are minimal considering the fact that no fuel is needed. Cost of a geothermal power plant is determined mainly by plant capital and drilling and exploring in almost equal proportion.

Considering power output, capital cost per kilowatt is higher for geothermal power plant comparing to other sources of energy which means for the same output, cost of construction of geothermal power plant is higher. On the other hand, the fact that drilling and exploration drives of setting up a geothermal plant may end up finding inadequate resource which poses yet another question to its reliability. Not only private investors but also government thinks twice to fund a project with such a high risk quotient.

In order to deal with the high initial coast, public private partnership (PPP) can reduce the burden on a single investor wherein the project would be funded by both government as well as private companies. Along with this, large companies should be encouraged to take up projects by government using tools like tax incentives and easy loans. This has to be augmented with improving the exploration and drilling technologies. There is also need to survey the site for the resources. It has been found that power cost can be reduced by maintaining full generation capacity by drilling make-up wells, for at least 10 years or so following plant startup. Also low operating cost together with long plant life and high efficiency of geothermal power plants can potentially balance out high initial costs. .

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2. Environment

Environmentally it is not a big challenge comparatively to other renewable and non-renewable resources as it is environment friendly but there are certain problems we encounter which include toxic chemicals which are present in geothermal fluid, production of minor emissions and seismic activity. Geothermal fluid can contain heavy concentrations of salt, as well as harmful chemicals and heavy metals like hydrogen sulfide, arsenic, boron, mercury, lead, and aluminum. These minerals in geothermal reservoirs are problematic because they are capable of polluting local environments and water sources. To prevent environmental contamination, geothermal fluids are injected back into different reservoirs from where they were extracted. The thick casings of geothermal wells prevent the geothermal fluid from coming in contact with groundwater during this process. To prevent runoff from escaping into local ecosystems, geothermal developers collect the surface runoff from geothermal power plants into impervious holding ponds.

Geothermal power plants typically accelerate the release of carbon dioxide from a geothermal reservoir into the atmosphere. The practice of regularly injecting fluid back into the reservoir, however, can mitigate this effect because the injected fluid absorbs carbon dioxide that would otherwise seep into the atmosphere. In addition to carbon dioxide emissions, geothermal plants emit hydrogen sulfide, a toxic and flammable gas that is naturally present in many geothermal reservoirs. H2S can be controlled by using certain chemicals and equipment and converting it into elemental form of hydrogen and sulphur. Some methods which are employed to achieve the target are:

i. Removing H2S from condensate

Treating the dissolved H2S is to direct the condensate to the cooling tower and adding chelated iron to the cooling water. The chelate or ligand (L) is usually EDTA, ethylene diamine tetraacetic acid.

ii. Removing H2S using scavengers

If the amount of H2S to be removed from the non-condensate gases is in less amount, it is economical to employ an H2S scavenger such as SULFUR RITE®. The system consists of an iron-based material, which is made to react with H2S to form innocuous iron pyrite which is also known as fool's gold.

iii. Removing H2S using liquid redox system

A process called LO-CAT II is the most widely used liquid redox system. This Process employs a non-toxic, chelated iron catalyst, whose work is to accelerate the oxidation reaction between H2S and oxygen which results into elemental sulfur.

Seismic activity can be minimized which is induced by the fractures that is drilled into the earth's crust by reducing its size. The larger the fracture created, the more seismic activity induced. Generally, the seismic activity caused by geothermal energy production is notable, but not a serious threat.

3. Enhanced Geothermal Systems

Production of geothermal energy is confined to some areas only due to certain specific characteristics or requirements. Geothermal power needs presence of heat along with water to be vaporized into stream and also sufficient accessibility through rock openings.

The development of Enhanced Geothermal Systems (EGS) could dramatically increase geothermal potential. In EGS, water is injected into deep rocks to re-open the natural fractures and allow hot water or steam to flow into extraction wells at high pressure. Continuous injection keeps these fractures open and provides a constant source of water to be heated up and extracted for electricity production.

III.BIOMASS ENERGY

A. Introduction

Biomass is immensely available and renewable source of energy and its sources comes from plants and animals. The process involved in absorbing sun's energy is called photosynthesis. On burning biomass, chemical energy is released in the form of heat. Biomass can be burned directly or converted to liquid biofuels or biogas that can be burned as fuels. Examples of biomass and their uses for energy: wood and wood processing wastes—burned to heat buildings, to produce process heat in industry, and to produce electricity, agricultural crops and waste materials—burned as a fuel or changed to liquid biofuels food, yard, and wood waste in garbage—burned to generate electricity in power plants or converted to biogas in landfills animal manure and human sewage—converted to biogas, which can be burned as a fuel.

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Biomass is an industry term for getting energy by burning wood, and other organic matter. Despite of emitting carbon on burning biomass has been classed as renewable source in EU & UN legal frameworks as plant stocks can be regrown again. Biomass has gained popularity among coal power stations and they have shifted from coal to biomass to use renewable energy generation without wasting existing infrastructure. Biomass includes most plants which are non-consumable and this type of biomass is specifically called lingo-cellulosic biomass.

B. Environmental issues:

The environmental working group identified there many feedstock issues that were relevant to the development of biomass as a significant energy source in United States and others. Rather they delved into issues that might require some resolution prior to an expansion of biomass energy systems to large-scale commercialization. The issues were loosely grouped into three areas:

i. The strongest argument for developing DFSS is the ability to improve environmental quality by providing an alternative to fossil fuels (especially coal), thus reducing the emissions of greenhouse gases. Coal and biomass are solid fuels that are easily converted to thermal energy. For both economic and ecological reasons, new biomass energy combustion and gasification systems should have greatly improved efficiencies which would result in their becoming very clean energy sources. Refineries built for the production of liquid fuels from biomass will also require high efficiency in their conversion processes to become economically feasible.

ii. Issues relevant to the establishment and maintenance of DFSS

iii. Issues relevant to any use of biomass for energy. The ranking of relative importance of the issues differed, depending on whether the end use was anticipated to be a large biofuel facility in the Midwest or a moderately sized electric generating.

iv. The energy characteristics of coal and biomass are similar. Coal and biomass are solid fuels that are easily converted to thermal energy.

C. Disadvantages and ways to mitigate them:

1. Gasification

Gasification is a sensitive process. Disagreement about gasification among engineers, researchers and manufacturers is quite common. Operation of all kind of biomass is often claimed by all manufacturers. More than half hour is needed by gasifier to start the process. For continuous running of system frequent refueling is required. Handling residues such as ash, tarry condensates time consuming and dirty work.

2. Gas production

Producer of gas is not difficult, but obtaining in the proper state is the challenging task. The physical and chemical properties of producer gas such as energy content, gas composition and impurities vary time to time. Requirement for size of fuel, ash capacity and moisture are strained in gasifiers. Fuel preparation is an important cause of technical problems with gasifiers.

3. PEMFC

A Proton Exchange Membrane Fuel Cell (PEMFC) is becoming an alternative for power generation device. Using biomass to produce hydrogen via a gasification process makes the integrated system of the PEMFC and biomass gasification a potential power production technology. Using this technology, we produce clean and green gas

IV.CONCLUSION

In this paper, efforts have been made to highlight the problems of renewable resources and ways to reduce their severity or to overcome them to open new doors for their implementations.

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