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Alternative Sources of Fuel and Sustainable Development

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Abstract: The world we see now is changing rapidly from the first man mission to the moon to robotic surgeries. Each sector is advancing towards sustainable development. Energy has been the driving force behind world progress and economic growth. We cannot think about the overall progress of mankind without transitioning towards efficient, clean, and green energy sources. This review article aims to highlight alternative sources of fuel for sustainable development. The demand for energy increases as society becomes more complex but the usage of traditional fossil fuels affects the environment and their depletion has raised concerns about the future of energy sources. Henceforth the need for alternative sources of fuel has become the need of the hour. Some of the alternative sources of fuel include solar power, wind power, hydropower, geothermal power, and biomass. As the energy revolution continues, we will soon find ourselves living in a world with less air pollution and pollution-related health hazards.

Keywords: Renewable energy, Biomass, Fossil fuels, Global warming.

I. INTRODUCTION

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy, are non-renewable resources that take hundreds of millions of years to form. Fossil fuels, when burned to produce energy, cause harmful greenhouse gas emissions, such as carbon dioxide. Approximately 80 percent of the total amount of energy used globally each year comes from fossil fuels. It is the primary source of energy in the world right now because it is energy-rich and relatively cheap to process but the fossil fuel supplies are limited and burning them releases heavy loads of carbon dioxide in the atmosphere.

This means that nonrenewable resources are limited in supply and cannot be used sustainably. In our world, non-renewable resources are getting depleted due to an increase in population and rising energy demands [1,2]. To ensure our future generation of a clean and green environment we should transition to renewable energy sources. Our effort in this paper has been to compare the various energy sources depending on various factors which will prove to be a suitable energy source keeping in mind the environment, economy, and geography of a location. Sunlight is the most abundant and freely available energy source but the amount of solar energy we use depends on the time of the day and season. To harness electricity from wind, turbines are used to drive generators but not every property is suitable for wind turbines. Hydropower can often be more reliable than solar or wind power for commercial use [3]. By building a dam or barrier, a large reservoir can be used to create a controlled flow of water that will drive a turbine, generating electricity.

Geothermal energy is produced by harnessing the natural heat below the earth's surface and generating heat. Biomass energy is energy generated or produced by living or once-living organisms. The energy from these organisms are converted into electricity or burned to create heat. Sand battery is a renewable source of energy, it is a high temperature thermal energy storage that uses sand or sand-like materials as its storage medium [4]. It stores energy in sand as heat. Its main purpose is to work as a high-power and high-capacity reservoir for excess wind and solar energy. The energy is stored as heat, which can be used to heat homes, or to provide hot steam and high temperature process heat to industries that are often fossil-fuel dependent [5].

II. EXPERIMENTAL

Solar power works by converting energy from the sun. It is generated by solar thermal systems which use the sun's energy to provide hot water and solar photovoltaic (PV) and concentrating solar power (CSP) systems follow the same to provide electricity. Solar PV cells are made up of PV modules which are interconnected networks of PV cells that convert solar energy into DC electricity typically in the range of 50 to 200W.

Wind Power is a renewable form of energy that is harnessed by converting wind energy into a more advantageous form. Wind turbines and windmills are used to generate electricity, wind pumps are for pumping water or propelling ships. Wind turbines placed in areas with steady winds use spinning rotor blades to turn a shaft that is connected to a generator.

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Hydropower is the power derived from the energy of moving water. The energy from moving water can be converted into electricity with the help of turbines. The kinetic energy of water is harnessed to generate this power. Hydropower is generated from water movement in the hydrological cycle when it is driven by solar radiation. The water from a river, dam or reservoir is made to flow through a penstock which carries the water under high pressure and when this water strikes the blades of a turbine, it converts the kinetic energy from the flowing water at high speed into mechanical energy. Now, the spinning turbine is connected to a generator which, through the process of electromagnetic induction, converts the mechanical energy to electrical energy. This current is then transferred to the power grid for customer usage [6]. Biomass feedstock can be converted to clean energy fuels using biotransformation technologies in bio refineries. Biomass can be converted into bioenergy which can further be converted into electricity by means of thermo-chemical and bio-chemical conversion processes like combustion, pyrolysis, gasification, and anaerobic digestion. Firstly, biomass is burned to produce heat in the combustion process. This heat drives a turbine connected to a generator. Then in the next step called gasification, biomass is heated in a low-oxygen environment to release syngas which is further burned to produce electricity. Anaerobic digestion involves breaking down organic waste into biogas, mainly methane using microorganisms which is burned to generate electricity. Using these processes, we can exploit the renewable and carbon-neutral nature of biomass. The use of the anaerobic digestion process to generate electricity using organic waste can help convert waste into useful energy [7]. Heat storing sand batteries are used for capturing and storing heat energy for later use. Sand is used as a storage medium for concentrated solar power plants. It comprises a high-temperature sensible heat storage system with a tank that contains sand as a storage medium and a heat exchanger. It is a three-phase process that includes the charging phase where Heat Transfer Fluid (HTF) is heated and the heat is transferred to the sand. As soon as the temperature of the sand reaches 150°C the phase is completed, the storing phase measures the thermal energy sand retains over a time period. [8]. Geothermal energy is the energy that exists as heat in the earth's interior. This large quantity of heat is transferred to a subsurface region initially by conduction and then by convection. Rainwater acts as a geothermal fluid that has penetrated into the Earth's crust from the recharge areas, has been heated on contact with the hot rocks, and has accumulated in aquifers, occasionally at high pressures and temperatures(up to above 300°C). These aquifers (reservoirs) are the essential parts of most geothermal fields. Wells are dug deep into these reservoirs to extract the hot fluids and they have varying uses like generation of electricity, space heating, and industrial processes [9].

III. RESULTS AND DISCUSSION

Renewable energy sources have their advantages as well as disadvantages. Table 1 shows the environmental impact and the carbon dioxide emissions from them. The manufacturing of solar panels requires the use of rare materials and use of a large amount of energy. Solar power plants generate a lot of e-waste after the plants are no longer functioning. Large-scale solar power plants use huge land areas which can lead to habitat problems. Wind energy has a low environmental impact just like solar power. Methane emissions pose a potential danger to climate change as they are found as decompositions in reservoirs. Biomass energy releases carbon dioxide and other greenhouse gasses during its combustion. Large-scale production of biomass uses a huge part of land area like solar power plants [10]. It may also release traces of toxic gasses and chemicals from underground which can harm the local air and water quality.

TABLE 1: ENVIRONMENTAL IMPACT OF RENEWABLE ENERGY SOURCES IN INDIA

Renewable Energy Source	Environmental Impact	Carbon dioxide Emissions
Solar Power	Low to moderate impact during manufacturing, for e-waste.	0.02%
Wind Power	Low impact on ecosystems and wildlife, slight visual and noise impacts	0.07%
Hydropower	Moderate impact on ecosystems and fish migration	0.1%
Geothermal Energy	Low greenhouse gas emissions, localized environmental effects	0.05%
Biomass	Moderate impact on land use, potential emissions and deforestation	0.2%

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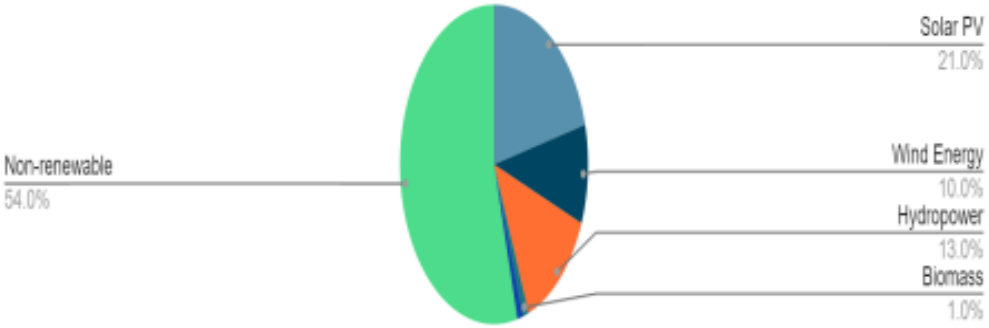

Fig. 1 Renewable Energy Sources Distribution in India's Electricity Generation

In Figure 1 if we try to compare the energy efficiencies of the various energy sources hydropower stands at the top with up to 90% efficiency. Solar energy is efficient with the range of15%-40% but without any effective energy storage solutions it does not perform its best. Hence sand batteries can be a solution to this for thermal energy storage. Wind energy is a clean source of energy and also very economical but its efficiency is 25%-40%.Biomassenergy is at 20% and geothermal at 40%.Fossil fuels have lower efficiencies but nuclear and hydropower have high energy efficiency [11].

Wind energy is to date the most successful in India. Tamil Nadu, Gujarat, Karnataka, and the western and southern coast regions have a good potential to harness wind power. Hydropower projects have been a great success in India. Some of the large-scale hydropower projects are Bhakra Nangal, Tehri, and Sardar Sarovar dams. They have successfully met India's electricity demands but due to environmental concerns small-scale projects have been on the rise rather than the large ones, especially in the hilly regions. Sugar mills, agro-processing units, and other small-scale industries use Biomass power. Chhattisgarh, Madhya Pradesh, Gujarat, Rajasthan and Tamil Nadu are the leaders in biomass projects.

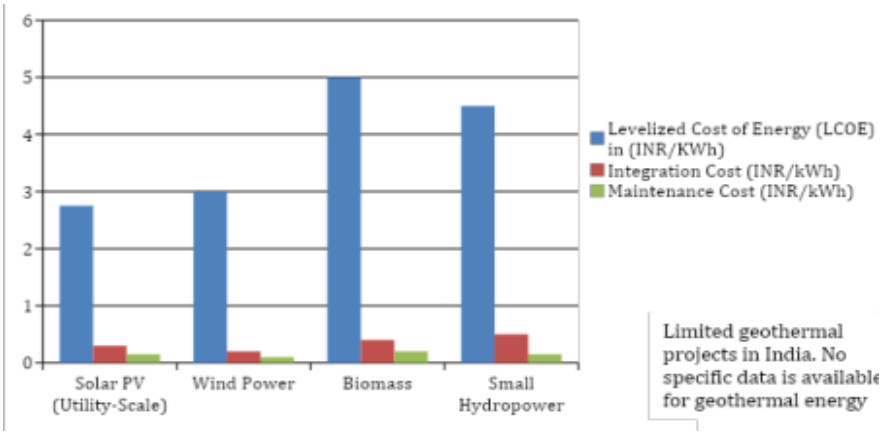

Figure 2: Cost-effectiveness of renewable energy sources in India

Cost-effectiveness is an important factor that determines the sustainability of a renewable energy source and it plays a vital role in determining if the source can be widely adopted in a country like India. In Figure 2, we have compared the renewable energy sources based on their Levelized Cost of Energy (LCOE), Integration Cost, and Maintenance Cost. Solar energy is a very cost-effective source that requires low maintenance costs and is relatively easier to integrate into the grid. It is abundant in most parts of India and is a great choice for large-scale utility projects across the country. States like Rajasthan, Telangana, Madhya Pradesh, Karnataka, Uttar Pradesh, and Tamil Nadu are just some of the places among several others which favor cost-effective generation of solar power considering the abundance of sunlight throughout the year in India [12].

Wind energy requires suitable locations and a consistent wind resource but is a very cost-effective and economical choice in suitable places. With relatively low integration and maintenance costs, wind energy is a feasible energy choice for windy regions in India. The feedstock availability and the technology play a crucial role in determining the costs incurred on biomass energy. Hydropower is a good option for places with suitable water sources and has a relatively higher integration cost as compared to solar and wind power projects [13].

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IV. CONCLUSION

Renewable energy sources are one of the essential ways through which sustainable development can be achieved. The authors have tried to present a thorough study of the renewable energy sources which should be adopted for a clean green future. To achieve sustainable development we need to understand the phenomena of the various renewable energy systems, increase our reliability on them, improve the collection and conversion efficiencies. We should adopt efficient energy storage solutions, use public transportation and e-vehicles, change our lifestyle, implement proper waste management system and decarbonize the existing energy sources. We know that the environmental impacts should be minimal to achieve sustainable development but since all sources leave impacts on the environment some way or the other, we can tackle that problem with increased energy efficiency. Furthermore, due to the increasing world population, we can no longer rely on fossil fuels to meet all our energy demands and the exploitation of renewable energy sources plays an important role in achieving sustainable development due to its increased flexibility, low environmental impacts and its abundant supply.

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