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3. Comparative Analysis of Renewable Energy Sources for Power Generation in India

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ABSTRACT

Renewable energy deployment in India is driven by a desire to boost the country's economy, increase energy security, broaden people's access to electricity, and slow the rate at which the planet is warming. Use of renewable energy sources and providing universal access to clean, cheap power are essential to achieve long-term sustainability. India is now one of the world's leading renewable energy marketplaces because to the country's supportive government and improving economic climate. Foreign investments are needed to rapidly expand the renewable energy market, thus the government has created regulations, initiatives, and a liberal environment to entice them.

Over the next few years, the renewable energy industry is expected to provide a sizable number of new jobs in the United States. The purpose of this paper is to discuss the progress made in India in the field of renewable energy, including recent and future accomplishments, projections, electricity generation, obstacles, investment opportunities, and job openings. As part of this analysis, we have catalogued the many challenges that the renewable energy industry has had to encounter. Policymakers, innovators, project developers, investors, industries, linked stakeholders and departments, researchers, and scientists can all benefit from the advice offered in the review's conclusions.

KEYWORDS:

renewable energy; renewable energy policies; renewable energy use; energy policy.

Introduction:

Renewable energy comes from resources that are continually renewed by the forces of nature. It comes from the sun and the earth's interior in a variety of ways. Renewable energy encompasses all forms of energy that come from non-depletable sources, such as solar, wind, biofuels, geothermal, and hydropower.

In keeping with this concept and the relevant literature, RES can be broken down into seven subcategories [5]: (i) hydro; (ii) geothermal; (iii) solar; (iv) tide/wave/ocean; (v) wind; (vi) solid biofuels, biogases, liquid biofuels; and (vii) renewable municipal waste.

One-third of worldwide greenhouse gas emissions have come from the combustion of fossil fuels like coal, oil, and natural gas used in electricity generation. Providing cleaner, more reliable power is crucial to improving people's living conditions and thus raising the standard of living. Energy consumption in India is on the rise to support the country's ambitious ambitions for economic growth. Increasing energy production is a crucial prerequisite for a country's economic development. The Ministry of Power (MoP) has produced a 10-year detailed action plan called the National Energy Strategy [NEP] with the goal of providing electricity throughout the country, and has also prepared a plan to ensure that power is given to citizens effectively and at a reasonable cost. In accordance with the 2017 World Resource Institute Report. Almost 6.65% of global carbon emissions may be attributed to India, placing it fourth behind China (22.83%), the United States (14.36%), and the European Union (9.66%). Also at stake is the world's delicate natural equilibrium, which climate change may disrupt. [1-5]

Future of renewable energy in India:

With energy and environmental problems on the rise, India has no choice but to prioritise renewable energy in its energy infrastructure of the future. There is a broad spectrum of renewable energy technologies, each with its own level of development and market penetration. Renewable energy is only getting started in India, but there are still many obstacles that need to be overcome by the country's enterprises, industries, governments, and users. Large-scale development and deployment of renewable energy projects are planned for India, which has abundant renewable energy resources (solar PV, wind, solar heating, small hydro, and biomass). Reaching the target of generating 10% of the country's electricity from renewable sources by 2012, as well as other lofty goals related to the rollout of biogas plants, solar PV applications, and solar cities, appears feasible. Furthermore, the existing gap that is preventing the use of quota for renewables might be overcome with the introduction of marketable renewable energy certificates (REC), thereby creating a thriving market. [6]

India will need to reach out to other countries for help with renewable energy in order to complete well-defined research and development projects that allocate roles and duties fairly and share the costs and benefits of their efforts. From the perspectives of long-term energy supply security, environmental benefits, and climate change mitigation, India places a premium on the development of renewable energy sources. In its report on integrated energy policy, the government acknowledged the importance of diversifying energy sources and developing domestic supply choices to their fullest potential. The Committee's focus is on increasing the proportion of renewable energy used across the board. In 2031-2032, the potential contribution from renewables in electricity generation alone is estimated to be 60,000 MW. By 2031-2032, renewables will have emerged as the primary factor in bringing the world's poor into the development process. In the next quarter century and a half, the renewable energy industry is expected to receive investments of around Rs 300,000 crores, at a very low estimate. Energy equity, affordability, availability, and access are all goals of MNRE [7]. Increasing the percentage of clean power is another objective.

Here, we outline the history and progress of the most promising renewable energy supply technologies:

1.Hydro power: Water's potential and kinetic energy can be used to power watermills, textile machines, and other similar devices, or converted directly into mechanical or electrical energy, making hydropower another viable renewable energy option (i.e., hydroelectricity generation). The term is used to describe the power that can be extracted from liquid water (rainfall flowing into rivers, etc.). When it comes to electricity production, hydropower is by far the most widely employed renewable energy source. A mere seventeen percent (17,000 MW) of the enormous (150,000 MW) hydel potential has been utilised thus far. The hydropotential of countries like Norway, Canada, and Brazil has been utilised at or above 30%, while India and China have trailed far behind. When it comes to hydropower potential, India is among the top five worldwide. The Central Electricity Authority (CEA) estimates that India has 148,700 MW of hydropower potential that may be developed at a profit. At now, hydropower is the world's leading renewable energy source for electricity generation. Production of hydroelectricity has skyrocketed in the last 50 years. In 1950, it was 340 TWh, or approximately a third of the world's total power demand.

2. **Wind power**: Complex interactions between the Earth's rotation, the sun's heat energy, the cooling effects of the seas and polar ice caps, the differences in temperature between land and sea, and the physical effects of mountains and other impediments combine to create the wind. Energy from the wind may be found all around the world. By the end of 2006, global wind capacity had reached around 72,000 MW. Wind energy is appealing in the developing world because it can be deployed fast in locations where electricity is urgently needed, and it is being developed in the industrialised world for environmental reasons. However, if fossil fuels are in short supply, this may be a cost-effective alternative. Also, wind energy has various uses in off-the-grid areas around the world, whether it's to replace more expensive diesel power or to power specific structures like farms and homes. Since 1995, wind power's installed capacity has skyrocketed from 4.8 MW to more than 239 GW in 2011. Each modern wind turbine can now produce as much power as a small nuclear reactor. The United States (with 47 GW), Germany (with 29 GW), and China (with 62 GW) are the three countries with the largest installed capabilities for wind energy.

3. **Solar power**: Direct solar energy (solar radiation) and indirect solar energy (wind, biomass, hydro, ocean, etc.) make up the majority of the world's accessible permanent energy resources. The thermal route uses the heat in solar energy for water heating, cooking, drying, water purification, and other applications; the photovoltaic route converts the light in solar energy into electricity, which can then be used for a variety of purposes including lighting, pumping, communications, and power supply in un electrified areas. Solar power's financial viability for household, business, and manufacturing use has been studied for the past two decades.

4. **Geothermal:** To put it simply, geothermal energy is that which is harnessed from the earth's latent heat, or the amassing of underground thermal energy.

The core, mantle, and crust of the Earth generate and store tremendous amounts of thermal energy. About 10,000 MW is being contributed globally by geothermal energy at the moment, and India's modest resources can increase that amount. Geological surveys in India

have uncovered evidence of over 340 thermal springs across the country. There are seven different geothermal regions where you can find them. Although the provinces are dispersed across a 1500 km stretch of the Himalayas, they are most numerous in Gujarat and Rajasthan on the western coast and in a west-south-west-east-northeast line stretching from the western coast to the western border of Bangladesh (known as SONATA). The resource sees limited use at present, but the government has an ambitious ambition to more than double the existing total installed producing capacity by 2012.

5. **Other renewable sources**: Biomass, waves, and tides are some more renewable energy options. Biomass consists of all organic material, including plant and animal life as well as human and marine trash.

Objectives:

1. The ultimate objective of the renewable energy policy is to increase the share of renewable energy source in India's energy mix.
2. We study of development of the main renewable energy supply technologies.
3. Analysing futures of renewable energy.

Review Of Literature:

In 1986, the first wind farm with 55 kW Vestas wind turbines was installed along the coasts of Maharashtra (Ratnagiri), Gujarat (Okha), and Tamil Nadu (Tuticorin). The Ministry of New and Renewable Energy has funded these experimental endeavours (MNRE). As of 31 August 2016, India's total installed capacity of wind power was 27,676.55 MW, with most of it located in the southern, western, and northern areas. However, at the end of 2015, India had the world's fourth-largest installed wind power capacity, despite being a relative newbie to the wind sector compared to countries like Denmark and the United States. [8]

The renewable energy performance of countries around the world has been analysed using a ranking approach by Arioglu Akan et al. There are a total of seventeen indicators employed, all of which pertain to the state of renewable energy capacity or generation as of the year's end 2013 and annual investment, net capacity additions, and production in 2013. According to this system, the top 15 nations in terms of renewable energy performance are (in descending order): China, the United States, Germany, Brazil, Spain, Italy, Denmark, Canada, Japan, Sweden, Turkey, Austria, Cyprus, India, and Portugal. Some of these nations' renewable energy strategies are described in greater detail in the next section of the study. [9]

To assess the performance and economics of integrated wind/hydro/diesel power plants with pumped storage, Sinha (1992) estimated a model for a hypothetical site. The components of his model include a diesel generator, a pump, and a method for converting wind energy. When using renewable energy sources like wind and water, the data reveal that pumped storage has little to no effect. It might be useful, nevertheless, in places where no natural water flows in. The greenhouse gas emissions from hydropower plants were discussed by Gagnon (1997), who demonstrates that hydropower is a viable alternative to fossil fuel power plants.

These findings suggest that traditional fossil fuel power plants emit between 30 and 60 times more greenhouse gases per unit of energy produced than renewable energy sources do. [10-11]

According to Ngô and Natowitz (2009), two major issues with relying on wind power are the variable nature of the wind and the high price tag of getting that power to homes and businesses. Offshore wind turbines are seen as a feasible alternative to land-based turbines, especially in places with limited land resources or when local populations are opposed to the installation of wind turbines due to aesthetic concerns. Denmark is home to the world's largest offshore wind farm, which features 80 turbines each capable of generating 2 MW. Ngô and Natowitz state that because local demand is lower than electricity production, Denmark exports the vast majority of the power it generates from wind turbines. [12]

Gipe (1995) looked at two European and British case studies. While wind speeds between 5.0 and 6.5 metres per second were found to be adequate for use as a viable energy source in the study's northern European context, the average speed in Great Britain should be greater than 7.0 metres per second due to the tariff risk involved. Gipe claimed that wind turbines had a chance of succeeding if there is a market for generated power, which would allow some homeowners to recoup some of the cost of installing wind turbines by selling any excess power to the utility. To move forward with the transaction, the parties involved need to reach an agreement, and the pricing policy of the government will ultimately determine whether or not the deal is feasible. The installed capacity has been influenced by the divergent pricing practises of the United States and Denmark. [13]

Research Methodology:

Some of the secondary materials we used to study the make-up, application, and effects of renewable energy were books, educational and development publications, government papers, and print and online reference sites. This paper provides a comprehensive summary of the methodologies utilised in the literature review on the valuation/evaluation of renewable energy resources. The primary and secondary criteria for the RE project's implementation have been identified, evaluated, and prioritised in this study. To ensure that India has a reliable supply of clean energy, we ranked the various RE sources based on the criteria listed above. Load profiles are analysed in tandem with the site's solar and wind potential. The system's architecture is then put together using a variety of parts. Financial variables and component sizing are both accounted for. After running the simulations, NPC, O&M, COE, and RF determine if the selected result is in line with the desired location.

Result And Discussion:

Research and development (R&D) in the renewable energy sector is a priority for the Ministry of New and Renewable Energy. When it comes to research and development (R&D), the government covers the full cost of a project, whereas the private sector often contributes only half. Initial phases of innovations with longer time horizons may receive a higher private sector R&D subsidy. About five percent of the country's power comes from renewables. Multiple renewable energy technologies have been implemented in both rural and urban settings over the past two decades.

Table 1: Renewable Energy in India

Sr. No	Source/System	Estimated potential	Achievement (as on 30 September 2008)
I	A power from renewables		
A.	Grid interactive renewable power	(MW)	(MW)
1.	Wind power	45,195	9521.80
2.	Bio power (agro residues and plantations)	16,881	656.60
3.	Bagasse cogeneration	5000	993.83
4.	Small hydro (up to 25MW)	15,000	2220.99
5.	Energy recovery from waste (MW)	2700	55.25
6.	Solar photovoltaic power	-	2.12MW
	Subtotal (A)	**84.776**	**13,4500.59**
8.	Captive/combined heat and power/ distrusted renewable power		
7.	Biomass/cogeneration (non-bagasse)	-	136.70
8.	Biomass gas fires	-	102.21
9.	Energy recovery from waste	-	31.07
	Subtotal (B)	-	269.98
	Total (A+B)	**84.776**	**13,720.57**
II	Remote village electrification		**5379 Villages/Hamble**
III	Decentralized energy systems		
10.	Family-type biogas plants	120 lakh	40.32 lakh
11.	Solar photovoltaic systems	50MW/Km^2	120 MWp
	i. Solar street lighting systems		70,474 nos.
	ii. Home lighting systems		434,692 nos.
	iii. Solar power plant		8.01 MWp
	iv. Solar power plant		7148 nos.
	v. Solar photovoltaic pumps		4,78,058 nos.
12.	Solar thermal systems	140 million m^2 of collector area	2.45 million m^2 of collector area
	i. Solar water heating systems		6.37 lakhs
	ii. Solar cookers		1342 nos.
13.	Wind pumps		723.00 kW
14.	Aero generators/hybrid systems		

Sr. No	Source/System	Estimated potential	Achievement (as on 30 September 2008)
IV	Awareness programs		
15.	Energy parks	-	516 nos.
16.	Aditya Solar Shops	-	269 nos.
17.	Renewable Energy Clubs	-	521 nos.
18.	District Advisory Committees	-	560 nos.
MW-mega-watt; m^2 – square meter; km^2 – kilowatt; MWp-mega watt peak			

Some of the achievements are given in Table 1 along with the estimated potential [14].

India's over-1028-million-strong population is increasing by an average of 1.58 percent each year. India may experience severe energy shortages in the next decades as a result of rising energy prices and an uncertain energy supply caused by the depletion of fossil fuels. The increased consumption of fossil fuels also contributes to regional and worldwide environmental degradation. The Indian economy is the twelfth largest in the world and has a GDP of roughly $1 trillion (using the US dollar as its primary currency) (2008). With a 9.0% GDP growth rate in 2007-2008, India is the world's second-fastest growing major emerging economy, behind only China. The need for power is skyrocketing.

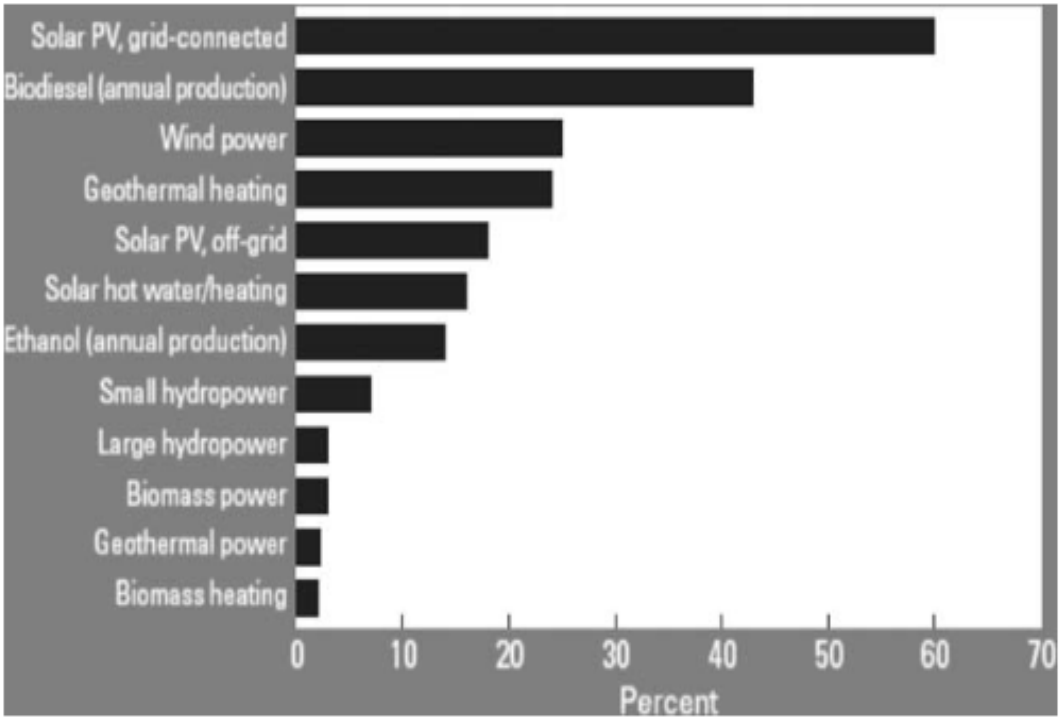

Figure 1: Average annual growth rates of renewable energy capacity

Including both conventional biomass and large-scale hydropower, as well as "new" renewables, these sources account for 18% of global final energy consumption (Fig. 1). (small hydro, modern biomass, wind, solar, geothermal, and biofuels).

Conclusion:

For the world's energy needs, renewables have become increasingly vital as concerns about climate change persist. The worldwide production and distribution of renewable energy sources is rising steadily. The NAPCC report claims that alternative renewable energy sources would be supported. Among the suggested courses of action is the encouragement of small wind electric generator development and manufacture, the promotion of straight (direct) biomass combustion and biomass gasification technologies, and the enhancement of the regulatory/tariff regime to facilitate the widespread adoption of renewable energy technologies. As a result, there is a greater emphasis on the introduction of renewable power, which is expected to make up around 5% of the electricity-mix by 2032. Some have recommended gradually replacing diesel and gasoline with blends that include alternative fuels, mostly bio-fuels, used primarily in transportation. Finally, it is projected that the share of renewable energy in the overall generation capacity will increase in the future because it delivers great benefits and may contribute considerably in the national energy mix at least economic, environmental, and social costs.

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