Current Status & Future Potential Of Renewable Energy In India

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Abstract

The application of renewable energy sources and technology may be able to address the long-standing energy problems that developing countries face. Renewable energy sources like wind, solar, geothermal, and ocean energy will be available in the future. For the past 25 years, India has been aggressively pursuing initiatives linked to the study, creation, testing, production, and use of diverse renewable energy technology for use in a range of industries. This paper aims to give a broad overview of India's renewable energy resources, taking into account their current availability, status, noteworthy achievements, and potential in the future. Furthermore, this study assesses specific legislative initiatives meant to reduce barriers and enhance the use of renewable energy sources in the future.

Keywords: Biomass, Solar Energy, Geothermal, Ocean Energy, Renewable Energy.

1. Introduction

According to predictions made by the World Energy Forum, the reserves of fossil fuel-based gas, coal, and oil will run out in less than ten more years. More than 79% of the world's primary energy comes from fossil fuels, of which 57.7% is used in transportation and is quickly running out [1]. Planners and policy makers are being driven to search for alternative energy sources due to the depletion of natural resources and the increasing demand for conventional energy. Renewable energy comes from resources that replenish themselves rather than running out over time. Our planet has the opportunity to lower carbon emissions, purify the air, and provide a more sustainable foundation for human civilization through the use of renewable energy. Additionally, it presents a global opportunity for nations to enhance their energy security and

promote economic growth. Modern biomass is essentially chemical solar energy storage, encompassing a variety of products obtained from photosynthesis. Figure 1 shows that 18% of the world's total energy consumption comes from renewable sources, which include major hydropower, modern biomass, wind, solar, geothermal, and biofuels in addition to traditional biomass and traditional biomass.

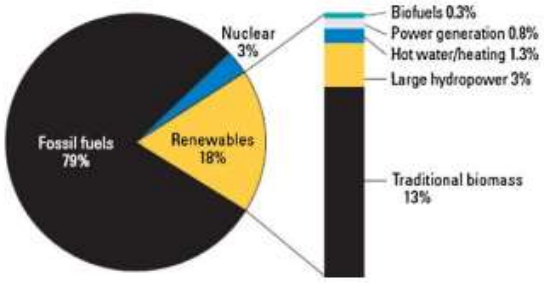


Fig. 1. Renewable energy share of global final energy consumption

About 13% of biomass is still utilized for traditional purposes, such as cooking and heating, and its share is declining in some areas as more modern energy sources replace or increase the efficiency with which biomass is used. Large hydropower makes up 3% of the total and is gradually increasing, mostly in emerging nations [2]. In developed and in certain developing countries, new renewables account for 2.4% of the total and are expanding extremely quickly. During the five years between 2002 and 2006, the capacity of various renewable energy sources, such as wind power, solar hot water, geothermal heating, and off-grid solar photovoltaics, increased at rates of 15–30% per year globally (Fig. 2) [3]. 2008 saw strong market growth for renewable energy. Wind power constituted the largest boost to renewable energy capacity among new renewables (large hydropower excluded). In 2008, an estimated $120 billion was invested globally in renewable energy, which included resources/phenomena into beneficial energies. Future prospects for the use of renewable energy resources as a replacement for conventional energy are bright. Thus, this paper reviews the renewable energy options that are currently available in India and offers details on their current state, future potential applications, notable accomplishments, and current government policies, delivery, and outreach in the Indian context. It presents an amazing overall picture of renewable energy resources and places India's use of these resources on a global scale.

2. India's Use of Renewable Energy

With around 1028 million people, India's population is expanding at a pace of 1.58% each year. India will experience severe energy shortages when fossil fuel energy becomes more scarce because of an increase in resources/phenomena into beneficial energies. Future prospects for the use of renewable energy resources as a replacement for conventional energy are bright. As a result, an effort has been made to address the energy dilemma, which is now mostly addressed by coal, foreign oil, and petroleum, all of which are bad for the environment in addition to being non-renewable and hence not a permanent answer. India must so transition from non renewable energy (coal and crude oil) to renewable energy in order to achieve energy security without negatively impacting the nation's thriving economy.

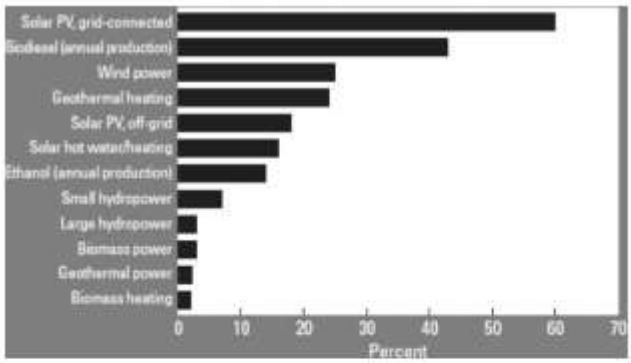
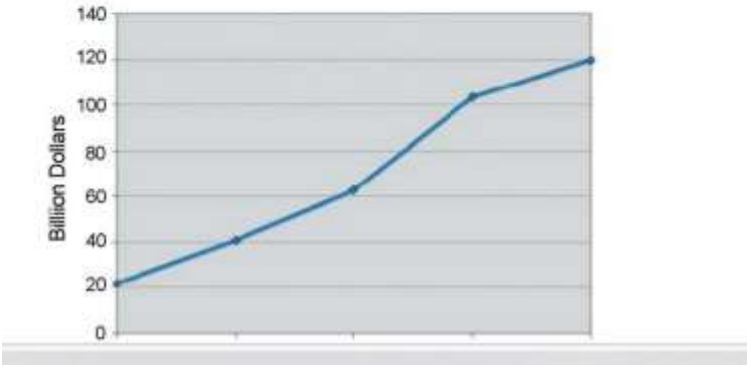


Fig. 2. Average annual growth rates of renewable energy capacity, 2002–2006.



These factors make the creation and application of RES and technologies essential to India's long-term economic growth. The World Energy Council's Asia Energy Vision 2020 expert consultation resulted in a consensus on India's energy demand projections through 2020, which are shown in Table 1 [6].

Table 1
Energy demand projection in India.

Sl. No.	Source	Unit	1991–1992	2009–2010	2020–2021
1	Electricity	TWh	231	725	1300
2	Coal	Mt.	229	690	1345
3	Petroleum products	Mt.	57	165	335
4	Natural gas	b cum	18.6	65	130

In its Report (IEPR 2006), the Expert Committee on Integrated Energy Policy projected that by 2032, or 25 years from now, the nation's primary commercial energy requirements would need to increase by 4-5 times the current level, installed capacity for electricity generation by 5.6–7 times, and oil requirements by 3-6 times the current level. In every area of the Indian economy, energy is a fundamental necessity for economic growth. Therefore, India must act swiftly to adopt energy-efficient and newly developed renewable energy technologies as well as energy India must therefore swiftly adopt energy-saving legislation and turn its attention to cutting-edge renewable energy and energy-efficient technologies. In light of this, the nation must quickly create a sustainable energy development plan.

The two main pillars of a sustainable energy supply are the encouragement of energy conservation and the greater use of renewable energy sources.

Thankfully, India has a wealth of renewable energy resources at its disposal, including biomass, solar, wind, geothermal, and modest hydropower. It also operates one of the biggest renewable energy projects globally.

India is fortunate to have access to a wide range of renewable energy sources, such as ve its objective With the exception of huge hydro projects, renewable energy already makes up 12,610 MW, or 9% of the existing energy capacity. When combined with large hydro, the capacity is greater than 34%, or 48,643 MW, of the 144,980 MW total installed capacity. Figure 4 displays installed power capacity in India.

An estimated 85,000 MW of renewable energy may be produced in the nation from commercially viable sources, including biomass/bioenergy at 25,000 MW, small hydropower at 15,000 MW, and wind at 45,000 MW. Furthermore, India possesses the capacity to produce 35 MW per square kilometer with solar thermal and photovoltaic power. With the exception of hydropower plants with installed capacities more than 25 MW, renewable energy accounted for 10,243 MW, or 7.7%, of the installed capacity of electricity as of March 2007.

Wind power has advanced astronomically, and India now ranks sixth in the world with installed capacity of over 8757 MW [4–7].

With worries about the nation's energy security growing, the role of new and renewable energy has become more and more important in recent years. With an approximate investment of USD 3 billion, the renewable energy business has a turnover of USD 500 million. Just approximately 3500 MW of the estimated 100,000 MW power potential from RE have been used thus far. The Indian government has been working on developing a comprehensive strategy that would require the nation to adopt renewable energy sources, such as biomass, hydropower, wind, solar, and municipal waste, especially for government and commercial institutions.

The investment in renewable energy is primarily driven by the private sector. This is because of the government's assistance, which amplifies the impact of private capital. Nonetheless, during the Tenth Plan era, the budgetary allotment for renewable energy sources stays within the range of 0.1% relative to the total allocation. This is anticipated to During the Eleventh Plan (Table 2), an increase in this is anticipated [8].

Table 2
Allocation to renewable energy vis-a vis conventional energy sources [6].

Five-year plan (period)	Energy sector outlay (percentage of total plan outlay)	Percentage share in the total plan allocation			
		Power	Oil/gas	Coal	Renewables
Sixth (1980–1985)	28.1	16.7	7.8	3.5	0.1
Seventh (1985–1990)	28.2	17.4	7.3	3.2	0.3
Eight (1992–1997)	26.5	18.4	5.5	2.4	0.3
Ninth (1997–2002)	25.58	14.5	8.6	2.04	0.44
Tenth (2002–2007)	27.26	18.2	6.46	2.12	0.48

Table 3
Renewable energy in India at a glance [7].

Sl. no.	Source/system	Estimated potential	Achievements (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.	Biopower (agroresidues and plantations)	16,881	656.60
3.	Bagasse cogeneration	5000	993.83
4.	Small hydro (up to 25 MW)	15,000	2220.99
5.	Energy recovery from waste (MW)	2700	55.25
6.	Solar photovoltaic power	–	2.12 MW
	Sub total (A)	**84.776**	**13,450.59**
B.	Captive/combined heat and power/distributed renewable power		
7.	Biomass/cogeneration (non-baggase)	–	136.70
8.	Biomass gasifiers	–	102.21
9.	Energy recovery from waste	–	31.07
	Sub total (B)	–	**269.98**
	Total (A+B)	**84.776**	**13,720.57**
II	Remote village electrification		**5379 villages/hamlets**
III	Decentralized energy systems		
10.	Family-type biogas plants	120 lakh	40.32 lakh
11.	Solar photovoltaic systems	50 MW/km^2	120 MWp
	i. Solar street lighting systems	–	70,474 nos.
	ii. Home lighting systems	–	434,692 nos.
	iii. Solar lanterns	–	697,419 nos.
	iv. Solar power plant	–	8.01 MWp
	v. Solar photovoltaic pumps	–	7148 nos.
12.	Solar thermal systems		4,78,058 nos.
	i. Solar water heating systems	140 million m^2 of collector area	2.45 million m^2 of collector area
	ii. Solar cookers	–	6.37 lakhs
13.	Wind pumps	–	1342 nos.
14.	Aero generators/hybrid systems		723.00 kW
IV	Awareness programs		
15.	Energy parks	–	516 nos.
16.	Aditya Solar Shops	–	269 nos.
17.	Renewable Energy Clubs	–	521 nos.
18.	Distric Advisory Committees	–	560 nos.

MW = mega-watt; m^2 = square meter; km^2 = kilowatt; MWp = mega watt peak

MNRE (www.mnre.gov.in).

The Indian government's eleventh five-year plan for new and renewable energy projects that the country's renewable energy sector will grow to an estimated US $19 billion between 2008 and 2012. To add the estimated 15,000 megawatts (MW) of renewable energy to the current installed capacity, investments of US $15 billion will be needed. Additionally, the Indian government has set particular goals for renewable energy, expecting it to account for 4-5% of the country's electrical mix and 10% of all power producing capacity by 2012. This suggests that the rise of renewable energy will happen far more quickly than the creation of traditional power, with renewables making Next in line are biomass (500 MW), cogeneration (1200 MW), and small hydro (1400 MW). The Ministry of Nonconventional Energy Sources is primarily concerned with developing and upgrading water mills, establishing commercial enterprises, renovating and modernizing, and evaluating the country's resources centered on corporate research and development.

Research and development in the field of renewable energy has been deemed crucial for the growth of this industry by the Ministry of New and Renewable Energy. In government R&D institutions, R&D subsidies cover 100% of project costs; in the private sector, they cover 50%. The private sector's R&D subsidy could be increased for newer technologies with longer

time horizons. Currently, roughly 5% of the nation's total power generating capacity comes from renewable sources. Numerous renewable energy solutions have been implemented in both rural and urban regions over the past 20 years. Table 3 lists a few of the accomplishments and their anticipated potential [9]

2.1. Biomass Around 14% of the world's ultimate energy consumption comes from biomass, which has garnered more attention as an energy source in recent years [10]. By 2050, estimates suggest that 15–50% of the primary energy used worldwide may originate from biomass. The rising utilization of renewable resources is now part of the political agenda in many countries. One such resource that might be very important in creating a more varied and sustainable energy mix is biomass. Unlike fossil fuels, using biomass energy does not, in theory, contribute to the atmosphere's concentration of carbon dioxide, a major greenhouse gas. Instead, biomass energy is a type of renewable energy. According to estimates, photosynthesis generates 220 billion dry tonnes of biomass year with a conversion efficiency of 1% worldwide [11–13]. A vast variety of materials can be classified as biomass resources appropriate for energy generation, ranging from crops farmed for energy production in agriculture and forestry to firewood gathered from natural forests and farmlands. Food wastes and food processing wastes, particularly wasted edible oils, appear to be promising sources of energy production when taking into account sustainability of bioresources, environmental preservation, and economic factors. India has a potential of 16,881 MW and is particularly rich in biomass. India has a potential of 16,881 MW (agro-residues and plantations), 5000 MW (bagasse cogeneration), and 2700 MW (energy recovery from waste) due to its abundance of biomass [7]. In India, the biomass power production sector employs more than 10 million man-hours annually in rural regions, generates more than 5000 million units of electricity, and draws investments totaling more than Rs. 600 crores annually.

2.2. Hydroelectricity

Another renewable energy source is hydropower, which transforms the kinetic or potential energy of water into electrical energy (i.e., hydroelectricity generation) or mechanical energy for use in textile mills, watermills, and other machinery. It alludes to the energy that comes from water, such as when rainwater runs into riversThe most common

renewable energy source used to produce electricity is hydropower. So yet, only approximately 17% of the enormous 150,000 MW of hydropower potential has been used.

While China and India have fallen far short of their hydropotential, nations like Brazil, Canada, and Norway have all been using more than 30% of their potential. In the globe, India has the fifth-highest exploitable hydropotential. India has 148,700 MW of economically viable hydropower potential, according to the CEA (Central Electricity Authority). Table 4 [14] displays the assessed potential for each basin.. The regions of North-Eastern India—Arunachal Pradesh, Assam, Nagaland, Manipur, and Mizoram—as well as the west coast between Mumbai (Bombay) and Mahe experience the majority of the country's yearly rainfall. Bihar, Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat, and Andhra Pradesh are the states with primary hydroelectric power plants. Small hydropower (SHP) refers to hydropower projects in India with a maximum station capacity of 25 megawatts (MW). About 11% of India's projected 15,000 MW of SHP potential has been used thus far. The development of SHP projects is aided nationwide by the Ministry of New and Renewable Energy (MNRE). With a total installed capacity of 1705 MW, 523 SHP projects have been installed thus far. In addition to this, 205 SHP projects totaling 479 MW in capacity are being implemented. With an average annual capacity addition of 100 MW and a steady reduction in capital costs and gestation durations, the SHP sector is starting to compete more and more with other options.

Table 4
Basin wise assessed hydropower potential [11].

Basin/Rivers	Probable installed capacity (MW)
Indus basin	33,832
Ganga basin	20,711
Central Indian river system	4152
Western flowing rivers of southern India	9430
Eastern flowing rivers of southern India	14,511
Brahmaputra basin	66,065
Total	148,701

Narmada Hydroelectric Development Corporation website.

2.3. Wind Power

The earth's rotation, solar radiation, the cooling effects of the oceans and polar ice caps, temperature differences between the land and the sea, and the physical effects of mountains and other impediments are some of the intricate processes that cause winds. One abundant source of energy is wind. By the

end of 2006, the total wind capacity worldwide was approximately 72,000 MW.

In the developed world, wind energy is being produced for environmental reasons, and itThe industrialized world is developing wind energy for environmental reasons, and developing nations are drawn to it because it can be swiftly erected in places where electricity is desperately needed. If fossil fuel supplies are not easily accessible, it could often be a more affordable option. Wind energy is also widely used in distant areas across the world, either to supply farms, residences, and other installations individually or to complement diesel power, which is sometimes costly.

There are variations in wind availability throughout different regions. The best places to use wind resources are those with a minimum wind power density of 400 W/m2 at 30 m above the ground. The organization executing the Wind Resource Assessment Program isthe earth.The Centre for Wind Energy Technology (C-WET) is executing the Wind Resource Assessment Program in collaboration with state nodal authorities. At 211 wind monitoring stations spread across 13 states and union territories—Andaman and Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttaranchal, and West Bengal—an annual mean wind power density greater than 200 W/m2 (watts per square meter) at 50-m height has been recorded. It has been estimated that India has 45,000 MW of wind power potential. Up until March 31, 2008, wind power added 8757 MW of capacity (Fig. 5) [4]. In India, the Wind Power Program was started in 1983–1984, near the conclusion of the Sixth Plan. The program's objectives are to survey and evaluate wind resources, establish pilot projects, and offer financial incentives to raise the cost of wind power.

Germany is the only country that has faster-growing wind energy markets than India. The subcontinent installed more wind generating capacity than the United States, Denmark, Britain, and the Netherlands by the middle of the 1990s. Some of the earliest wind turbines ever installed in India were the 10 devices located in the Gujarati province near Okha. The Arabian Sea is visible from these 15-meter Vestas wind turbines. Although there is a 5310 MW installed capacity as of 2008, there is a tenfold potential, or 45,000 MW, available. India uses a variety of wind power generators, including water-pumping windmills, aero-generators (small wind electric generators with a capacity of up to 30 kW), and wind-solar hybrid systems, for the production of off-grid power [15].

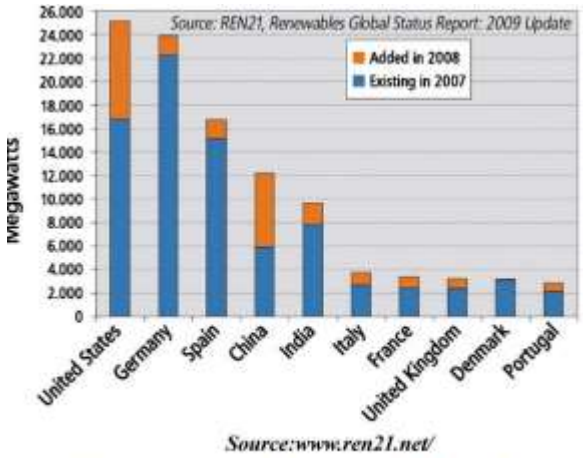


Fig. 5. Wind power capacity, top ten countries, 2008.

2.4. Solar Energy

The most plentiful permanent energy source on earth is solar radiation, which can be used directly or indirectly through wind, biomass, hydropower, the ocean, etc. There are two ways that we can use solar energy, which we experience as heat and light: the thermal route uses the heat for cooking, drying, heating water, purifying water, producing electricity, and other uses; the photovoltaic route turns the light in solar energy into electricity, which can be used for a variety of uses, including It can then be utilized for a variety of tasks such power supply in non-electrified locations, lighting, pumps, and communications.

The world's annual primary energy consumption of 450 EJ is less than 7500 times the total amount of solar radiation that falls on the planet. Approximately 3,400,000 EJ of solar radiation reach the earth's surface each year, which is an order of magnitude more than all estimated non-renewable energy resources (both discovered and undiscovered), including nuclear and fossil fuels. Nonetheless, fossil fuels provide for 80% of the energy used globally today. With 250–300 bright days a year, the majority of India receives 4-6 kWh of solar radiation per square meter daily. Western Rajasthan receives the most yearly radiation energy, yet the solar power heat, which we perceive as heat and light, may be used in two ways: thermally, it can be used to heat water & cook.

The photovoltaic pathway turns light from the sun into electricity, which may subsequently be utilized for a variety of functions like lighting, pumping, communications, and power supply in places that are not electrified. Other applications

include drying, water purification, power generating, and others.

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2.5. Geothermal Energy

Geothermal energy is produced by the accumulation of heat that has been absorbed from below the surface of the earth. The Earth's crust, mantle, and core generate and store enormous amounts of thermal energy. Currently, geothermal energy contributes roughly 10,000 MW globally; India's limited resources have the potential to increase this amount. The Indian Geological Survey's research has revealed that there are roughly 340 hot springs in the hot nation. There are seven geothermal provinces in which these are spread. The provinces are most common in a west south west-east-northeast line that runs from the west coast to Bangladesh's western border (known as SONATA), while they are also found along the west coast in Gujarat and Rajasthan

3. Additional Methods for Renewable Energy

The most popular solar thermal technologies are solar water heating systems, solar cookers, and solar generating systems. Policies are in place to encourage the spread of solar technology even more.

An alternate energy source that is mostly made from organic wastes is biogas. For more than thirty years, biogas produced from animal waste—mainly cow dung—has been encouraged for usage in India. The anaerobic digestion of a range of organic wastes, including those from agriculture, industry, homes, and animals, produces biogas, a clean fuel. The only technology that has elevated cooking in rural regions to a higher technological level and made it enjoyable, with accompanying social and environmental benefits like zero interior pollution, is biogas.

Since the early 1980s, one of the methodical and well-organized programs to offer institutional and logistical support has been biogas development (NPBD), which has been in operation.

When compared to other programs of this type that are undertaken in rural India, the India Biogas initiative is among the most successful. Under the National Biogas Program, more than 3.7 million biogas units with a capacity of 1-6 m3 had been erected as of December 2004.

The eventual objective of this program is to install biogas plants in about 12 million households with sufficient cattle to ensure a steady supply of manure.

The nation's biofuel initiative is only getting started. Since the early 1980s, one of the methodical and well-organized programs to offer institutional and logistical support has been biogas development (NPBD), which has been in operation.

When compared to other programs of this type that are undertaken in rural India, the India Biogas initiative is among the most successful. Under the National Biogas Program, there were about 3.7 million biogas plants with a capacity as of December 2004.

As of right now, the government has reduced the excise tax on E-5, mandated that all gasoline in some places be blended with 5% ethanol since January 2003, and regulated the price at which ethanol is sold based on the cost of producing the fuel. It is then intended to raise the proportion of ethanol combination in gasoline to 10%. The development of hydrogen energy is likewise in its early stages. The development of hydrogen energy technology has also been the subject of research programs financed by the Ministry of New and Renewable Energy.

India is a participant in the International Partnership on Hydrogen Economy (IPHE), which was established in November 2003 in Washington, DC.

India's future challenges include developing compact and affordable storage capacity, creating a hydrogen network, developing hydrogen-fueled internal combustion engines, lowering the cost of hydrogen significantly and improving production rates from various methods, and improving the efficiency of various fuel cell systems. The road map envisions launching research, development, and demonstration initiatives in a number of hydrogen energy technology domains, with the end objective of achieving one million hydrogen-fueled automobiles and one thousand megawatts of combined hydrogen-based energy.

4. Climate Change and Renewable Energy in the Environment

Energy is needed to maintain economic growth and enhance living standards. Supply could be increased to make up for

shortages. However, social progress and environmental sustainability are two more crucial factors. With many of these effects originating from the energy sector, the current pattern of economic growth has seriously damaged the environment, damaging biological systems, polluting the air, and speeding up climate change. It is crucial to take into account the impact on social development at the same time. Lack of access to energy services exacerbates a number of socioeconomic issues, such as inequality, unemployment, poor health, and poverty.

Oil is one of the primary energy sources in contemporary economic sectors. While the top oil consumer in the world is still United States, China is ranked second, Japan is ranked third, India is ranked fourth, and the Republic of Korea is ranked sixth among the Asian nations [17]. Natural gas is also becoming more and more significant because of its fuel economy, which attracts new power plants and the industrial sector.

Waste disposal, especially nuclear waste, and water pollution are other environmental issues. The overuse of environmentally delicate places is a concern in rural communities.

In rural areas, a large number of people rely on biomass fuels for lighting, cooking, and warmth. Overuse of these may result in habitat loss, biodiversity loss, and watershed degradation. The energy sector accounts for around 70% of global greenhouse gas (GHG) emissions, mostly from the burning of fossil fuels for transportation, heat, and electricity production. There are numerous ways for nations to reduce their greenhouse gas emissions—at zero, modest, or even net negative costs. These include alterations in lifestyles, increased efficiency, improved energy management, and cleaner production and consumption in addition to energy conservation. The use of more energy-efficient technology, such as renewables, would also help slow down global warming. In general, nations have the ability to support evidence-based policymaking that increases people's access to contemporary energy services and provides incentives for greener and more energy-efficient commercial endeavors.

4.1. Variations in Climate

Climate change brought on by greenhouse gas emissions from burning fossil fuels, particularly carbon dioxide (CO2), has been linked to global warming, substantial ecosystem disruption, and an estimated 150,000 extra fatalities annually [2]. The primary cause of this increase is the unsustainable usage of The

primary causes of this increase are changes in land use and the unsustainable use of fossil fuels [18].

4.2. Methodology for Clean Development

The Kyoto Protocol's clean development mechanism (CDM) was established to help developing nations achieve sustainable development by supporting initiatives to reduce greenhouse gas emissions. These initiatives produce emission credits, or certified emissions reductions, or CERs, for industrialized nations [19]. The CDM is being utilized by several nations in the area.

This clause is part of the Kyoto Protocol, which was first designed as a bilateral system that allowed organizations in developed nations to get certified emission reductions (CERs) by funding clean technology in developing nations.

In poor nations that receive the aid, this might increase returns on For wind, hydro, and geothermal projects, this can increase returns by up to 12%; for biomass and municipal waste projects, it can increase returns by up to 15% to 17% (UNEP).

Over 379 million CERs have already been committed to by Indian businesses. By 2012, investments made globally are expected to yield 1.9 billion CERs.

5. India's Future with Renewable Energy

India's only choice, given its dual environmental and energy issues, is to seek to increase the role of sustainable in the energy systems of the future. The level of technological advancement and commercial viability of renewable energy solutions varies greatly. Renewable energy is just getting started in India, and before these technologies really take off, there are a lot of difficulties that enterprises, industry, the government, and consumers need to resolve. India is expected to have extensive development and implementation of renewable energy projects due to its abundance of renewable energy resources (solar PV, wind, solar heating, small hydro, and biomass) [20]. By 2012, 10% of the nation's electricity will come from renewable sources, and there are also big plans forIt looks that the deployment of biogas plants, solar PV applications, and solar cities—all of which have grandiose plans—are doable. Additionally, the current barrier impeding the deployment of renewable energy could be closed with the establishment of tradable renewable energy certificates (REC).quota for renewable energy sources and therefore develops a thriving industry.

Additionally, India would need to seek for international assistance in sustainable energy through clearly defined research and development projects, appropriate labor and task division, fair financial burden distribution, and credit sharing plans.

India views the growth of renewable energy as being extremely important in terms of long-term energy supply security, environmental advantages, and mitigating climate change. The necessity to maximize development has been acknowledged by the Integrated Energy Policy study. to fully explore domestic supply alternatives and the requirement for energy source diversification. The Committee has prioritized using more renewable energy sources for all types of services. In 2031–2022, it is anticipated that the share of renewable energy in power generation alone could reach 60,000 MW. Renewables will be the main force behind the social inclusion of the impoverished in the development process by 2031–2022. Over the next 25 years, investments in the renewable energy sector are estimated to total over Rs. 300,000 crores. Energy security, a rise in the proportion of clean electricity, energy availability and access, energy affordability, and energy equity are all part of MNRE's purpose [21].

Many governmental and non-governmental entities Research and development (R&D) on renewable energy sources is carried out by a variety of public and private institutions, including the MNRE, the Center for Wind Energy Technology, universities, IITs, NITs, Indian Oil Corporation Ltd. (IOCL), and The Energy Resource Institute (TERI).

6. Energy Policies

The primary aim of the framework for renewable energy policy is to considerably augment the proportion of renewable energy sources in India's energy composition [20]. The government sets these energy-related regulations.

6.1. The 2005 National Electricity Policy

The following goals are the focus of the National Electricity Policy: Access to electricity, availability of power demand (to be fully met by 2012), overcoming energy and peaking shortages and having spinning reserves available, supply of dependable and quality power of specified standards in an efficient manner and at reasonable rates, increasing per capita availability of electricity to over 1000 units by 2012, financial turnaround and commercial viability of the electricity sector,

and protection of consumers' interests are the goals of the National Electricity Policy.

6.2 The 2003 Electricity Act

The following are provisions of the Electricity Act that deal with non-conventional energy sources.

As per the provisions of Sections 3(1) and 3(2), the National Electricity Policy and Tariff shall be prepared and published periodically by the Central Government. Tariff Policy, in collaboration with state governments and authorities for the development of the electricity grid based on the most efficient use of energy resources, including coal, natural gas, nuclear materials or substances, hydropower, and renewable sources. According to Section 4, the federal government must draft and announce a national strategy allowing stand-alone systems for rural areas after consulting with the state governments. According to sections 61, 61(h), and 61(i), the appropriate commission must, in accordance with the provisions of this Act, specify the terms and conditions for determining the tariff. In doing so, the commission will be guided by the National Electricity Policy and Tariff Policy, as well as the promotion of cogeneration and the generation of electricity from renewable sources of energy.

Section 86 (1) According to Sections 86(1) and 86(1)(e), the state commissions are responsible for carrying out the following duties: encouraging cogeneration and the production of electricity from renewable energy sources by offering appropriate measures for grid connectivity and sale of electricity to any individual, and additionally designate a portion of the overall electricity consumption within the jurisdiction of a distribution license for purchases of electricity from such sources.

6.3. The 2006 Tariff Policy

The following clauses are included in the Tariff Policy that was declared in January 2006:

1. In accordance with section 86 (1) (e) of the Act, the Appropriate Commission is required to determine a minimum proportion for the purchase of energy from these sources, considering the impact on retail tariffs and the availability of these resources in the area.

2. Before non-conventional technologies can rival conventional sources in terms of electricity cost, considerable time will need to pass. Consequently, distribution companies must use

preferential tariffs that are established by the relevant commission while conducting procurement.
Distribution Licensees must, to the greatest extent feasible, use a competitive bidding process under Section 63 of the Act to select suppliers who provide energy from similar nonconventional sources for such future requirements.
In the event that non-firm electricity is procured through non-competitive bidding, the Central Commission ought to establish criteria for pricing non-firm power, particularly from unconventional sources, within a three-month timeframe.

6.4. Policies for National Rural Electrification, 2006

1. The objectives include giving all families access to energy by 2009, providing a dependable and high-quality power supply at affordable prices, and requiring a minimum lifeline usage of one by year 2012 as a merit good per unit/household/day.
In villages or habitations where grid access is impractical or not cost-effective, stand-alone system-based off-grid electricity supply solutions may be adopted.
3. The state government is required to create and publish a rural electrification plan, outlining the delivery system for electricity, within a span of six months.
4. The village's electrified status as of March 31st of each year must be certified and confirmed by the Gram Panchayat.

6.5. Planning Commission, Integrated Energy Policy Report, 2006

Provide a plan for achieving the energy needs of theProvide a plan for integrating the nation's energy demands until 2031–2022. It suggested placing extra emphasis on the development of renewable energy.

7. Programs and Actions for Distribution and Outreach

7.1. Committees for District Advisory (DAC)

These Committees have resulted in the establishment of a grassroots, successful network for the promotion of renewable energy, which will facilitate the integration of renewable energy programs with those of other development departments. 550 DACs have been established in 550 districts around the nation as of right now.

7.2. Shops Selling Sustainable Energy, Akshay Urja

The establishment of Akshay Urja Shops around the nation's districts aimed to guarantee convenient access to these

systems and gadgets. The general public is anticipated to adopt renewable energy technology in a

7.3. Parks with Energy

Energy Parks were established nationally as a means of combining the operations of State and District Levels.

7.4 Mahatma Gandhi Railjiv Gandhi Renewable Energy Day, or Akshay Urja Diwas

On August 20, 2006, the nation celebrated "Rajiv Gandhi Akshay Urja Diwas," a nationwide awareness-raising initiative at the national, state, and local levels. Gandhi was the former prime minister and is now deceased.

7.5. The Renewable Energy Newsletter, Akshay Urja

With an emphasis on national and international renewable energy breakthroughs, technological advancements, manufacturer specifics, renewable energy education, etc., a bi-monthly newsletter named "Akshay Urja" was launched.

7.6. Clubs for Renewable Energy

A plan has been developed to encourage the study of renewable energy by establishing RE Clubs in engineering colleges and technology institutions around the nation that have been recognized by AICTE and approved. The goal of these clubs is to inform and acquaint upcoming scientists with the various facets of new and renewable energy.

8. Notable Accomplishments

India has made significant progress in developing renewable energy, which can be summed up as follows:

More than 4200 MW of grid power are derived from solar, wind, biomass, and small hydropower.

Approximately 3600 isolated villages and hamlets, such as those in the North East, Bangladesh, Ladakh, and the Sunderbans, are powered by solar energy.

Largest solar-steam cooking system in Tirupati Tirumala Devasthanam, capable of feeding 15,000 people per day.

Installed solar water heating systems covering an area of approximately 7 lakh square meters.

3.5 million biogas plants have been set up.

There are about 35 million upgraded wood stoves in rural houses.

860 blocks have the Integrated Rural Energy Program in place.

Solar photovoltaic devices with a capacity of about 30 MW are exported to both developed and developing nations.

280 Energy Parks have been established in educational institutions to showcase renewable energy systems and equipment.

Up to yet, beneficiaries and users of renewable energy systems and devices have received direct subsidies of Rs. 25,000 million, which includes funding for grid-connected renewable power installations.

The Indian Renewable Energy Development Agency Limited has so far loaned Rs. 32,000 million for 1600 renewable energy projects.

The Center for Wind Energy Technology was established in Chennai, Tamil Nadu, as a scientific and industrial research institution for wind resource assessment, equipment certification, and R&D.

Conclusion

Every nation in the world's national energy policy is driven by three factors: economic growth, energy security, and environmental protection.

Given the high cost of crude oil, there is a global need to increase efforts towards the research and promotion of renewable energy sources. Promoting renewable energy technology will be a crucial component of the answer to issues with competitiveness, health costs, environmental degradation, economic growth in the face of growing energy prices, and energy security. The NAPCC claims that promotion would be given to alternative renewable energy sources. A number of specific action items have been identified, such as encouraging the use, development, and basic research of renewable energy technology, removing obstacles to the commercial development and deployment of biomass and hydropower.

Last but not least, renewable energy has a lot to offer and can offset a lot of the country's economic, environmental, and social expenses. It is anticipated that in the future, renewable energy will make up a larger portion of the nation's total generation capacity.

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