JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 7, ISSUE 03, 2020

Renewable energy in India:Current status and future potentials

Dheeresh Upadhyay[1] and Lokesh Kumar[2]

[1]Department of Electrical & Electronics Engineering, Mangalayatan University, Aligarh, UP

[2]Faculty of Engineering & Applied Sciences, Usha Martin University, Ranchi, Jharkhand

E-mail: dheeresh.upadhyay@mangalayatan.edu.in

Abstract

The developing nations' long-standing energy issues may be alleviated through the use of renewable energy sources and technology. Renewable energy sources including wind, solar, geothermal, ocean, biomass, and fuel cell technologies may be employed to alleviate India's energy crisis. India's fast-growing economy requires an energy supply three to four times more than what is now used. One way to address this need is via the use of renewable energy sources. About a third of India's main energy needs are met by renewable sources now. Increasingly, India is turning to environmentally friendly sources of energy such as solar and wind power in order to reduce carbon emissions, improve air quality, and secure the country's long-term viability. Research, development, demonstration, manufacture, and implementation of a wide range of renewable energy technologies has been a major focus in India over the last two-and-a-half decades. The purpose of this article is to provide an overview of India's renewable energy possibilities, including what's already available, where things stand now, and what's to come. Policy measures to overcome hurdles and increase renewable energy adoption are also examined in this article.

1. Introduction

According to the World Energy Forum, oil, coal, and gas supplies will be depleted in less than a century. Global primary energy consumption is dominated by fossil fuels, accounting for more than 79 percent of the total, and 57.7 percent of that quantity is utilised in the transportation sector [1]. Planned and policy makers have been driven to explore for alternatives because to the depletion of natural resources and the growing demand for conventional energy. A renewable energy source is a source of energy that does not decline over time, such as natural resources. With the help of renewable energy, we have the opportunity to cut carbon emissions, improve air quality, and establish a more sustainable society. Countries all across the globe may boost their economies and their energy security at the same time. As a kind of chemical solar energy storage, modern biomass includes a wide variety of goods produced from photosynthesis. 18 percent of the world's final energy consumption is provided by renewable energy,

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which includes conventional biomass, major hydropower, and "new" renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels). In certain locations, traditional biomass, mostly used for cooking and heating, accounts for around 13% of the total, although this is decreasing as biomass is more efficiently utilised or replaced by more contemporary types of energy. Large hydropower generates around 3% of global electricity and is expanding slowly [2]. Renewable energy sources now account for 2.4% of total energy consumption and are expanding at a fast pace in both developed and developing nations. Wind energy, solar thermal, geothermal heating, and off-grid SPV expanded at rates of 15–30 percent yearly over the five-year period 2002–2006 (Fig. 2) [3]. A substantial growth in the renewable energy sector was seen in 2008. Wind power was the most significant new source of renewable energy capacity expansion (apart from massive hydropower). This figure includes new capacity (asset finance and projects) as well as biofuels refineries that were built in 2008.

RES that rely on locally available resources

These technologies have the potential to produce energy with minimal emissions of air pollutants and greenhouse gases. The conversion of natural phenomena/resources into useable energies is at the heart of renewable energy technology. In the future, as a substitute for conventional energy, the use of renewable power resources seems to hold great promise. A study of the renewable energy choices available in India has been undertaken in this article in order to offer information on the existing state of renewable, future potentials of their usage, important accomplishments and govt regulations, delivery and outreach in Indian context. India's use of renewable energy resources and its place on the world map as a result of this portray a striking image.

1. **RenewableenergyinIndia**

Over 1028 million people call India home, and its population is rising at a pace of 1.58 percent each year. Due to rising energy costs and energy insecurity, India will confront significant energy shortfalls in the next several decades as fossil fuel energy diminishes. Fossil fuel usage is also causing environmental issues both locally and worldwide. India has a GDP of roughly $1 trillion, making it the twelfth biggest economy in the world when expressed in US dollars at today's exchange rates (2008). For the fiscal year 2007–2008, GDP grew at a rate of 9.0%, making it the second fastest large developing economy in the world behind China. As a result, the primary sources of modern energy are coal, foreign oil, and

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petroleum. These sources are not only nonrenewable and consequently unsustainable in the face of the present energy crisis, but they are also harmful to the environment. As a result, India must transition from using nonrenewable energy sources (such as crude oil and coal) to using renewable energy sources in order to ensure its economic growth.

For these reasons, the development and utilisation of RES and technologies are becoming more important for India's long-term economic growth. As shown in Table 1 [6], an expert panel convened under the auspices of the World Energy Council reached consensus on India's energy demand projections until 2020. Expert Committee on Integrated Energy Policy (IEPR 2006) estimates that the country's major commercial energy demand would need to increase 4–5 times by 2032, electricity production installed capacity 5.6–7 times the present level, and oil need by 3–6 times the existing level in 25 years time.

Every sector of the Indian economy relies on energy for growth and development. Thus, it is imperative that India immediately turn to new and developing renewable energy technology, as well as energy conservation regulations, to address the country's energy needs. As a result, a long-term strategy for energy growth is an absolute need for the nation. The twin pillars of a sustainable energy supply are energy conservation and growing utilisation of renewable energy sources. Biomass, sun, wind, geothermal, and minor hydropower are just a few of India's abundant renewable energy resources. The country is also executing one of the world's biggest renewable energy initiatives.

India is on a mission to become a global leader in sustainable energy generation. The Indian government has already put in place a number of measures and organisations to aid in the achievement of this aim. 9 percent of the total installed capacity of renewable energy excludes big hydro projects, which is 12,610 MW of electricity. When combined with big hydro, the installed capacity of 144,980 MW has a capacity of 48,643 MW, or over 34% of the total. Figure 4 depicts India's installed MW power capacity.

Around 85,000 megawatts (MW) of economically exploitable renewable energy resources exist in the nation, including 45,000 MW of wind, 15,000 MW of small hydro, and 25,000 MW of biomass / bioenergy. In addition, solar photovoltaic (SPV) and solar thermal energy can yield 35 MW per square kilometre in India. By the end of March 2007, renewable power, excluding hydro over 25 MW installed capacity, had provided 10,243 MW, or 7.7 percent of total installed capacity, to the grid. Wind power has made tremendous progress, and India now ranks fifth in the world in terms of installed capacity, with over 8757 MW [4–7].

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The rising worry about the country's energy security has made the role of innovative and renewable energy sources more important. The investment in renewable energy is roughly $3 billion, with an annual revenue of approximately $500 million. Only roughly 3500 MW of the projected 100,000 MW of RE potential has been used to far. For the last several years, the Indian government has been hard at work developing a comprehensive strategy for the mandatory use of renewable energy resources in the nation via biomass, hydropower, wind and solar power, as well as municipal garbage.

The business sector makes a significant contribution to investments in renewable energy. This is owing to the government's backing, which in turn encourages private investment in the sector. However, the financial allocation for renewable energy sources remains in the region of 0.1 percent of the overall allocation for the Tenth Plan. During the Eleventh Plan, this is predicted to rise (Table 2) [8].

Between 2008 and 2012, the renewable energy industry in India is expected to grow to $19 billion in value, according to India's 11th five-year strategy for new and renewable energy. In order to add the roughly 15,000 megawatts (MW) of renewable power to the current installed capacity, US $15 billion will be needed. To meet its 2012 aim of 10% of overall power generating capacity and a 4%–5% participation in the electricity mix, the Indian govt has also set specific targets for renewable energy. A far higher rate of expansion for renewable energy than for conventional power generating means renewables are expected to account for 20% of the extra 70,000 megawatts (MW) in power generation capacity projected from 2008 to 2012. 3075 MW of renewable grid-tied electricity was planned between 2002 and 2007, however the actual capacity augmentation topped 6000 MW in 2006 Wind energy in India has grown at a phenomenal rate in recent years. Next comes small hydro (1400 MW), co-generation (1200 Mw), and biomass (1200 Mw). Wind energy is predicted to contribute more than 10,000 Mw of capacity by 2012. (500 MW). Water mill development and modernization, national resource assessment, commercial project establishment, and industry-based research and development are among of the ministry's primary focuses.

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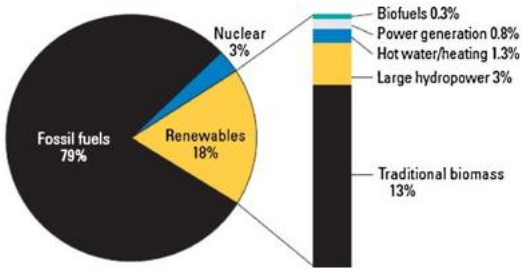

Fig. 1. Renewable energy share of global final energy consumption.

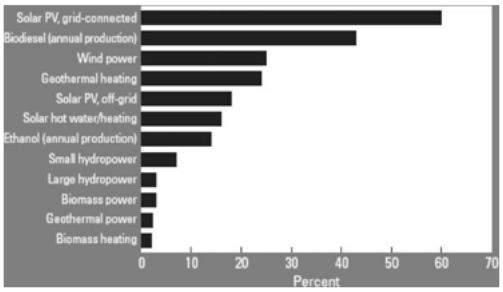

Fig. 2. Average annual growth rates of renewable energy capacity, 2002–2006.

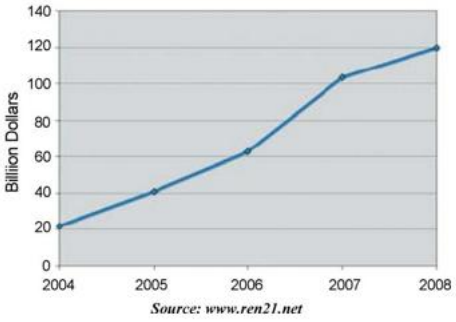

Fig. 3. Global investment in renewable energy, 2004–2008.

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

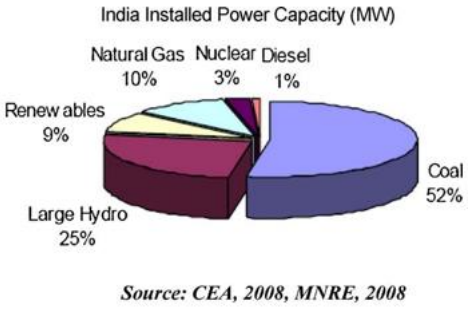

Fig. 4. Installed power capacity (MW) in India as of June 2008.

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

Renewable energy R&D has been identified by the Ministry of New and Renewable Energy as a key aspect in the development of this industry. A project's cost is subsidised to the fullest extent possible in government R&D institutes, and to a lesser extent in private companies. Private sector R&D subsidies may be increased for the early phases of long-term innovations. About 5% of the country's total producing capacity comes from renewable sources. Many renewable power technologies have been implemented over the past two decades in rural and urban locations. [9] Table 3 lists some of the accomplishments, as well as their predicted potential.

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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.	District Advisory Committees	–	560 nos.

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

MNRE (www.mnre.gov.in).

2.1. *Biomass*

Biomass has seen an uptick in attention as a fuel source in recent years and now accounts for 14% of global final energy use [10]. More than a quarter of the world's energy needs might be met by biomass by 2050, according to recent estimates. Increasing the usage of renewable energy sources has become a political priority for a large number of nations. One such resource, biomass, has the potential to play a significant role in a more varied and long-term supply of energy. Biomass energy is a renewable source of energy that does not contribute carbon dioxide, a significant greenhouse gas, to the environment, unlike fossil fuels. An estimated 220 billion dry metric tonnes of biomass are produced each year by photosynthesis across the world, with a conversion efficiency of 1 percent [11–13]. There is a vast variety of biomass resources that may be used for energy generation, from firewood found in agriculture and natural woodlands to crops developed specifically for this purpose. Depending on bio-resource sustainable development, environmental protection, and economic considerations, the use of food wastes or food processing wastes, particularly waste edible oils, seems to be desirable. There are 16,881 MW (agro residues and plantations), 5000 MW (bagasse cogeneration) and 2700 MW (energy recovery from waste) of biomass resources in India, which may be harnessed. More than Rs. 600 crores are invested each year in the biomass power production business in India, resulting in an annual output

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of more than 5000 million kilowatt-hours and over 10 million man-days of employment in rural regions.

2.2. Hydropower

Watermills, textile machines, and other mechanical devices may be powered by hydropower, which turns water's potential or kinetic energy into mechanical energy or electrical energy (i.e., hydroelectricity generation). Water energy (rainfall flowing into rivers, etc.) is what this term alludes to. Hydropower is the most widely utilised renewable energy source for generating electricity in the world today. Just over a third of the 150,000 MW total hydel potential has been harnessed so far. There has been a disparity in hydropower use between countries like Norway, Canada, and Brazil and India and China. India is the world's fifth-largest country in terms of hydropower potential that may be used. 148,700 MW of commercially viable hydropower potential exists in India, according to the Central Electricity Authority (CEA). Table 4 shows the basin-wide assessed potential.

Table 4
Basinwiseassessedhydropowerpotential[11].

Basin/Rivers	Pro insta babl lled(ecapMW) acit y
Indusbasin	33, 832
Gangabasin	20, 711
CentralIndianriversystem	415 2
Westernflowingriversofs outhernIndia	943 0
Easternflowingriversofso uthernIndia	14, 511
Brahmaputrabasin	66, 065
Total	148,701

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NarmadaHydroelectricDevelopmentCorporationwebsite.

Arunachal, Assam, Nagaland, Manipur, and Mizoram in India's northeast, as well as the western coast between Mumbai (Bombay) and Mahe, get the majority of the country's yearly rainfall. " Bihar, Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat, and Andhra Pradesh are the primary hydroelectric power plants in India." There are a number of minor hydropower projects in India that have a power station capacity of up to 25 megawatt (MW) (SHP). SHP potential in India is estimated at 15,000 MW, of which only 11% has been harnessed. SHP projects are supported by the Ministry of New and Renewable Energy (MNRE). A total of 1705 MW of installed capacity has been achieved so far by 523 SHP plants. In addition to this, 205 SHP projects totaling 479 MW are now under construction. The SHP industry is growing more and more competitive with other options because to annual capacity additions of 100 MW on average and decreasing gestation durations and capital costs.

SomekeyfiguresconcerningsmallhydroinIndia:

• Lessthan25MWisinthe ‘‘smallhydro’’designation	• 4096potentialsites havebeenidentified
• Thereisapotentialof 15,000MW	• Technologyismature andreliable
• Installedis1520MWtodate	• Twotypesoftechnology areused (i) High-headsystems (ii) Low-headsystems

2.2. ***Windenergy***

In addition to the earth's rotation, the sun's heat energy, ocean and polar ice cap cooling, land-to-water temperature gradients, and the physical impacts of mountains and other obstructions, wind is created through a variety of causes. Wind power may be found all around the world. At the end of 2006, the world's total wind capacity was around 72,000 MW. Aside from the obvious environmental benefits, wind energy is gaining popularity in the developing countries due to its ease of installation in remote places with a high demand for power. If fossil fuels aren't widely accessible, this may be a viable alternative. The wind energy may also be used to augment diesel power (which is costly) or to serve individual farms, residences, and other facilities in isolated places throughout the globe.

Depending on where you live, wind might be scarce or abundant. In places where the wind power concentration is at least 400 W/m2 at 30 m above the ground, wind resources may be tapped. C-WET (the Centre for Wind Energy Technology) is implementing the Wind Resource Assessment

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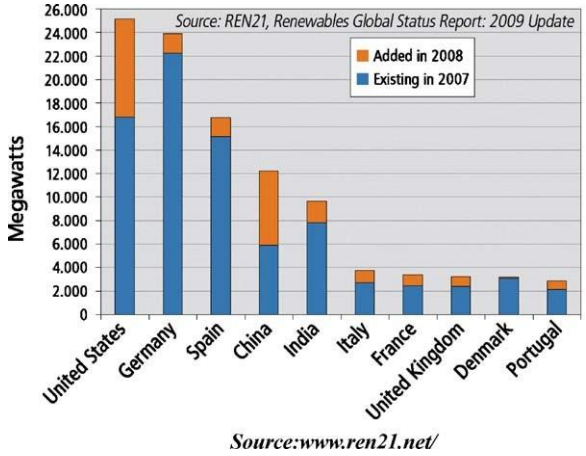
Program in collaboration with state nodal authorities. 211 wind monitoring stations covering 13 states and union territories, including the Andaman and Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Lakshadweep, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttaranchal, and West Bengal, have recorded an annual mean wind power density greater than 200 W/m2 (watts per square metre) at a height of 50 metres. Potential wind power capacity in India is around 45,000 MW. Wind power has so far added 8757 MW of new capacity as of March 31st, 2008. (Fig. 5) [4]. This programme began in the last year of India's Sixth Plan in 1983–84. Under this programme, wind resources will be studied and evaluated together with demonstration projects and financial incentives to help make wind power economically viable.

In terms of wind energy growth, India is only exceeded by Germany. India had installed more wind power capacity by the mid-1990s than any of these other countries combined. Some of the first wind turbines in India were erected at Okha in Gujarat province. The Arabian Sea may be seen from these 15-meter Vestas wind turbines. The installed capacity in 2008 is 5310 MW, but the potential is ten times more, or 45,000 MW. India uses a number of different kinds of wind power generators for off-grid power production, including water-pump windmills, aero-generators, and wind–solar hybrid systems [15].



Source:www.ren21.net/

2.3. *Solarenergy*

The sun's energy is the world's most plentiful, and it may be harnessed directly (through solar radiation) or indirectly (by wind, biomass, hydroelectricity, and the ocean, for example). The thermal route uses the heat for water heating, cooking, drying, water purification, energy production, and other applications; the solar cell route gets converted the light in solar energy into electricity, which can then be used for a variety of purposes, such as lighting, pumping, communications, and power supply in areas without

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electricity.
Global primary energy consumption per year of 450 EJ is 7,580 times more than the entire yearly solar radiation that falls on the Earth's surface. There are around 3,400,000 EJ of solar radiation hitting the Earth's surface every year. This is an order of magnitude more than all non-renewable energy resources, such as fossil fuels and nuclear. Fossil fuels account for 80 percent of the world's current energy use. There are 250–300 sunny days a year in most areas of India, with an average daily solar radiation dose of 4–7 kWh/m2. Western Rajasthan gets the most yearly radiation energy, whereas the North-Eastern part of India receives the least. India receives the solar energy equivalent of around 5000 trillion kWh each year, which is a considerable amount of solar radiation. According to location, the daily incidence varies from 4 to 7 kWh/m2 and the annual hours of sunlight vary from 2300 to 3200. A joint effort by the MNRE and the Indian Renewable Energy Development Agency (IREDA) aims to expand the market share of renewable energy in India by promoting the use of all kinds of solar power. R&D, demonstration projects, government subsidies, and private sector ventures are all involved in this promotion.

On June 30th, 2008, Prime Minister Howard Dean unveiled the National Action Plan to Combat Climate Change (NAPCC). The National Solar Mission [15] is one of eight missions proposed in the Plan. As a part of the Ministry's Solar Energy Program (considered to be one of the biggest in the world), solar thermal and SPV technologies are included. India's projected solar power potential is between 30 and 35 MW/km2. A total of 140 million m2 of collector area has been anticipated for India's solar water heating systems. Solar water heating systems in the household, industrial, and commercial sectors have been accelerated by the introduction of a government programme called 'Accelerated innovation and installation of solar water heating systems in domestic, industrial, and commercial sectors'. In addition to financial and promotional incentives, the programme provides various assistance measures. It has been used in a variety of industrial and agricultural operations, including drying/curing, regeneration of dehumidifying chemicals, lumber seasoning, and leather tanning; a variety of sun dryers have been designed for usage in diverse settings, as well. Solar air heating and drying systems, as well as solar concentrating systems, are both supported financially by the government. Efforts to boost energy efficiency have been made by the MNRE and Himachal Pradesh's state government to encourage passive solar design in building design. The Ministry's Solar Photovoltaic Program (SPV), which has been in place for the last two decades, is focused at rural and isolated locations. As a follow-up to the success of the SPV demonstration and usage programme during the Ninth Plan (2002–2007), it is intended to continue it throughout the Tenth Plan

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(2002–2007). The Ministry's goal is for everyone to have access to renewable energy sources by the year 2010[8].

2.4. Geothermalenergy

Geothermal energy is obtained from subsurface heat reservoirs or heat absorbed from the surface of the earth. The Earth's core, mantle, and crust create and store enormous quantities of thermal energy. Globally, geothermal energy contributes 10,000 MW, and India's resources may add to this figure. The geological survey of India has discovered over 340 hot springs amid the country's sweltering climate. Seven geothermal provinces are home to these. There are many provinces in India, but they are concentrated along a 1500-kilometer length of the Himalayas, known as SONATA, which runs from the west coast of Gujarat and Rajasthan to the Bangladeshi border. However, the Government has a goal of more than doubling installed generation capacity by 2012, and this resource is currently underutilised.

Secondly, there are other renewable energy technologies that may be used.

One of the most commercialised renewable energy technologies in India is solar thermal technology, which includes solar water heating, solar cooking, and solar power production systems. Solar technology will be given a boost in the coming years thanks to new policies.

As an alternative energy source, biogas is generated from organic wastes. In India, the usage of biogas made from cow dung has been encouraged for more than 30 years. Anaerobic digestion produces biogas, a clean fuel made from a wide range of organic wastes: from animal and agricultural wastes to home wastes and industrial wastes. With its related social and environmental benefits, such as zero interior pollution, biogas is the only technology to elevate rural cooking to the level of modern convenience. As one of India's well-organized and systematic programmes to offer logistic and organizational support for that has been implemented since the early 1980s, the National Project on Biogas Development (NPBD) in India If we compare it to other similar programmes in rural India, the India Biogas initiative is one of the best. Up to December 2004, about 3.7 million biogas units with a capacity of 1–6 m3 had been erected under the National Biogas Program. There are 12 million homes in the country with enough livestock to feed a biogas plant on a regular basis.

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The country's biofuel initiative is still in its infancy. An excise tax decrease has been implemented for E-5; the need to mix all gasoline in some places since January 2003; and the government has set the ethanol selling price in accordance with how much it costs to produce E-5. After then, the ethanol content in gasoline is expected to rise to 10%. We're working on a new national biofuel policy right now.

Hydrogen energy is still in its infancy. Additionally, research into several facets of hydrogen energy technology development was supported by the Ministry of New and Renewable Energy. As of November 2003, India is a member of the Washington, DC-based International Partnership on Hydrogen Economy (IPHE). Reduce hydrogen costs significantly and improve production rates using various methods are some of India's upcoming challenges. Others include developing compact and inexpensive hydrogen storage capacity, creating a hydrogen network, and working to develop hydrogen-fueled IC engines and fuel cell systems. The road plan envisions taking up research, development, and demonstration efforts in different hydrogen energy technology sectors and envisioning targets of one million hydrogen-fuelled cars and 1000 MW aggregate hydrogen based power production capacity in the nation by 2020 [16]. [16]

Renewable environmental and climate change are two important aspects of environmental sustainability.

Energy shortages might be alleviated by boosting supply in order to maintain economic development and enhance living standards. But there are also environmental and social factors to keep in mind. As a result of the present economic expansion, the environment has been harmed greatly, with many of these consequences originating from the energy industry. The influence on social development must also be taken into account. Poverty, illness, unemployment, and other societal ills are all exacerbated when people lack access to reliable energy sources.

Oil is one of the primary sources of energy in contemporary economic sectors. Despite the fact that the United States is the world's greatest oil user, China, Japan, India, and the Republic of Korea are all within striking distance [17]. Another reason natural gas is becoming more popular is because of its high fuel efficiency, which makes it an appealing option for new power plants and other industrial uses as well.

Water contamination and the proper disposal of trash, especially nuclear waste, are two further issues that need to be addressed. Overexploitation of ecologically vulnerable regions is a concern in rural communities. Biomass

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fuels are a common source of cooking, heating, and lighting for rural residents. These may have a negative impact on watersheds, biodiversity, and ecosystems if they are overused. The burning of fossil fuels for heat, power production, and transportation accounts for around 70 percent of global greenhouse gas (GHG) emissions. Reducing GHG emissions may be done with little or no cost, or even for a net benefit to the country. Energy conservation and efficiency improvements, improved energy management, greener production and consumption, and a shift in lifestyle are just a few of the options available to consumers today. Climate change may be mitigated through the use of renewable and more efficient technology. As a general rule, nations may encourage scientifically-based decision-making that encourages cleaner and more energy-efficient economic activity while extending access to energy for everyone.

4.1. Changes in the climate

There have been significant changes in ecosystems and an extra 150,000 fatalities per year due to climate change induced by global warming caused by greenhouse gases, primarily carbon dioxide (CO2). Fossil fuel consumption and land use change are the primary drivers of this increase [18].

Uncomplicated method of developing software

By supporting reducing emissions initiatives, the Kyoto Protocol's Clean Development Mechanism (CDM) helps poor nations achieve sustainable development by generating credits (CERs) for industrialised countries. The CDM is being used by a number of nations in the area. Investing in clean technology in developing countries may earn industrialised nations certified emission reductions (CERs) under a clause of the Kyoto Protocol that was originally intended as a bilateral approach. As a benefit to the receiving poor nations, this might increase project returns by up to 12 percent for wind, hydro and geothermal power projects, and by 15–17 percent for biomass and waste materials projects (UNEP). More than 379 million CERs have already been contributed by Indian businesses. By 2012, 1.9 billion CERs would have been invested throughout the world.

Renewable energy sources in India's future

In order to meet the country's dual energy and environmental concerns, renewable energy sources must play a larger part in the country's future energy systems. There is a broad range in the maturity and economic viability of renewable energy technology. A huge number of difficulties need to be resolved before renewable energy can be widely adopted in India. This includes challenges for enterprises, industry, government, and consumers.

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Large-scale renewable energy projects are expected to be developed and deployed in India due to the country's abundant renewable energies (solar PV, wind, solar heating, small hydro, and biomass) [20]. Ambitious plans for biogas plants, solar PV applications, and a solar city look to be within reach of achieving a 10% renewable power supply by 2012. A thriving market may be created by introducing tradable renewable energy certificates (RECs), which would close a current loophole impeding the implementation of renewable energy production quotas.

Global cooperation in renewable power will include India seeking out international collaboration via well defined R&D projects with appropriate divisions of labour and responsibility for specific tasks, as well as equal financial burden and credit sharing agreements. In terms of long-term energy supply safety, environmental benefits, and climate change mitigation, India places a high value on renewable energy development. The Integrated Energy Policy study has acknowledged the need of maximising domestic supply alternatives as well as diversifying energy sources. For the Committee, renewable energy is an important consideration. In the year 2031–2032, it is predicted that renewable energy would contribute 60,000 MW to electricity production alone. For the poor to be included in development by 2031–2032, renewable energy will be a major factor. About Rs. 300,000 crores will be invested in renewable energy over the next 25 years, according to a conservative estimate. One of MNRE's goals is to expand the percentage of clean electricity, as well as make it easier for the general public to get their hands on it and afford it.

Many government and corporate institutions, including the MNRE, the Centre for Wind Energy Technology, universities, IITs, NITs, Indian Oil Corporation Ltd. (IOCL), and The Energy Resource Institute (TERI), are active in R&D of renewable energy sources, such as wind turbines.

5. Energy policy

Increasing India's reliance on renewable energy sources is the overarching goal of this policy framework [20]. The government sets these energy regulations.

Section 6.1 National Electricity Policy

The National Electricity Policy aims to achieve the following goals: "access to electricity, availability of power demand (to be fully met by 2012), energy and peaking shortages to be overcome and spinning reserve to be available, supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates, per capita availability of electricity to be

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increased to over 1000 units by 2012, financial turnaround and commercial viability of the power sector."

Section 6.2 Power Act of 2003

Non-conventional energy sources are covered under the following clauses of the Electricity Act.

Sections 3(1) and 3(2) state that the central government, in consultation with state governments and authorities for the development of the power system based on optimal utilisation of resources such as coal, oil and gas, nuclear substances or material, hydro and sustainable sources of energy, shall periodically prepare and publish the National Electricity Policy and Tariff Policy. In accordance with Section 4, the Central Government must establish and announce a national policy allowing stand-alone systems in rural regions following consultation with the state governments. Under the provisions of this Act, the appropriate commission shall specify the terms and conditions for tariff determination, and in doing so, shall be guided by the following, namely the promotion of cogeneration and the generation of electricity from renewable sources of energy; and National Electricity Policy and Tariff Policy; Cogeneration and the production of electricity from renewable energies must be encouraged by the state commissions, who must provide suitable measures for the grid connection and the sale of electricity to any person, as well as specify a percentage of total consumption in the area of a distribution licence for purchasing electricity from such sources.

6.1. TariffPolicy,2006

As stated in January 2006, the Tariff Policy is comprised of the following:

It is mandated that the Appropriate Commission set a minimum proportion for the acquisition of energy from such sources in accordance with Section 86 (1) (e) of this Act, taking into consideration regional availability and retail pricing.

When it comes to power prices, it will be some time before alternative energy sources can compete with traditional ones. Therefore, the Appropriate Commission will set favourable pricing for purchase by distribution businesses.

As far as practicable, Distribution Licensees will acquire future energy needs via a competitive bidding procedure in accordance with Section 63

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of the Act, which governs the procurement of non-conventional energy.

For non-competitive purchase of non-conventional electricity, the Central Commission shall provide rules within three months for pricing non-conventional power, notably from non-conventional sources.

6.2. Rural Electrification in the United States

1. By the year 2012, a merit good of 1 unit/household/day must be achieved as a minimum lifeline consumption as a result of providing electricity to all houses.

2. Off-grid solution based on stand-alone systems may be used in villages and habitations where grid connection is neither practical or cost-effective.

Rural electrification plans, including how the service will be delivered, shall be prepared and made public by the state government within six months.

The Gram Panchayat is responsible for certifying and confirming that the village is electrified on the 31st March of each year.

The Planning Commission's 2006 Integrated Energy Policy Report

Propose a strategy for meeting the country's energy demands during the next decade, from 2031 to 2032. It was suggested that particular attention be paid to the development of renewable energy sources.

7. Delivery and outreach initiatives and actions

7.1. Advisory Committees for Districts (DACs)

In addition to promoting renewable energy at the local level, these Committees have helped to integrate renewable energy plans with those of other development agencies. DACs have been established up in 550 of the country's districts thus far.

The AkshayUrja Shops are 7.2 (renewable energy shops)

As a result, a nationwide network of AkshayUrja Shops was established to make these systems and equipment readily available to the public. The average man is anticipated to adopt renewable energy technology in a

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large manner to supplement the energy demands of cooking, lighting, and transportation from these establishments.

7.3. Parks for generating electricity

Energy Parks were established at the national level to integrate the operations of the State and District Levels.

7.4. The AkshayUrjaDiwas of Rajiv Gandhi (Rajiv Gandhi Renewable Energy Day)

'Rajiv Gandhi AkshayUrjaDiwas' was held throughout the nation on August 20th, 2006, in honour of the late Indian Prime Minister, Sh. Rajiv Gandhi, in order to raise public awareness.

The AkshayUrja Newsletter is published on the 7.5th of every month (Renewable Energy Newsletter)

The 'AkshayUrja' newsletter, published every two months, focuses on national and worldwide advances in renewable energy, technology advancements, manufacturer data, and renewable energy education.

The Clubs for Renewable Energy

Various elements of new and renewable energy are to be educated and sensitised to young and future scientists via the establishment of RE Clubs at AICTE recognized/approved Engineering Colleges/Technology Institutions throughout the country.

Major accomplishments

The following are some of India's most notable accomplishments in renewable energy development:

Wind, small hydro, biomass, and solar energy provide more than 4200 MW of grid electricity.

A total of 3600 distant villages and hamlets, including those in the Sunderbans, Bastar, Ladakh, and the North East, have been electrified using solar power.

Tirupati Tirumala Devasthanam has installed the world's largest solar–steam cooking system, capable of serving 15,000 people a day.

Solar water heating systems have been built with a collecting area of 7 lakh square metres.

Biogas plants for cooking and lighting have been installed in more than 3.5 million homes worldwide.

Approximately 35 million rural houses have updated wood stoves.

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It has been implemented in 860 parcels of land.

Products ranging from 30 MW to 30 MW capacity have been sold to a wide range of industrialised and developing nations.

In educational establishments, 280 Energy Parks have been established to demonstrate renewable energy systems and technologies.

Subsidies for grid-connected renewable power projects have been included in the Rs.25 billion in direct subsidies paid so far to recipients/users.

Indian Renewable Energy Corporation (IREC) has so far issued a loan in the amount of Rs. 32,000 million.

1600 renewable energy projects are being developed by Energy Development Agency Limited.

The Wind Energy Technology Centre was established as a research facility.

A wind resource assessment, equipment certification, and R&D business located in Chennai, Tamil Nadu.

Gurgaon, Haryana, has established a solar energy research and development centre.

9. Conclusions

National energy strategy is driven by three factors: energy security, economic development, and environmental preservation. The high price of crude oil has prompted a worldwide call for increased efforts to develop and promote renewable energy sources. Energy security, economic development, competitiveness, health care expenses, and environmental degradation may all be addressed in large part by supporting renewable energy technology. Various other forms of renewable energy will be encouraged, too, according to the NAPCC. To name a few, promoting the use of renewable energy sources like biomass, hydropower, solar power, and wind power has been mentioned as well as improving regulatory and technical frameworks and removing roadblocks to the development and commercial deployment of these sources. Promoting straight (direct) biomass combustion and biomass gasification has also been recommended. By 2032, renewable power is expected to account for roughly 5% of the country's total electrical supply, according to a recent report. There are plans to gradually replace diesel and petrol with alternative fuels, mostly biofuels, for transportation purposes. There are several advantages to using alternative sources of energy, including economic, environmental, and social costs; it is projected that the proportion of renewable energy in the overall generating capacity will rise over time.

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