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Renewable Energy for Sustainable Development in India: Current Status and Future Prospects

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Abstract **-Renewable energy sources and technologies have potential to provide solutions to the long-standing energy problems being faced by the developing countries. The renewable energy sources like wind energy, solar energy, geothermal energy, ocean energy, biomass energy and fuel cell technology can be used to overcome energy shortage in India. To meet the energy requirement for such a fast-growing economy, India will require an assured supply of 3–4 times more energy than thetotalenergy consumed today. The renewable energy is one of the options to meet this requirement. Today, renewable account for about 33% of India's primary energy consumptions. India is increasingly adopting responsible renewable energy techniques and taking positive steps towards carbon emissions, cleaning the air and ensuring a more sustainable future.**

Keywords- **Renewable energy sources, consumption, climate change, major achievements**

I.INTRODUCTION

Renewable energy is a term used to refer to forms of energy that are naturally obtained from the environment and from sources that can be replenished naturally. These include solar energy, wind energy, geothermal energy, hydropower, and biomass. The term renewable energy should not be confused with alternative energy, which describes sources of energy outside the regular forms like gasoline that are considered more environment-friendly or less harmful.

II. RENEWABLE ENERGY GENERATION

Total renewable energy which includes large hydro with pumped storage generation, is nearly 17.5% of total utility electricity generation in India during the year 2017–18.[16][17] Solar, wind and run of the river hydro being must run power generation and environment friendly, base load coal fired power is transforming in to load following power generation.[18] In addition, renewable peaking hydro power capacity also caters peak load demand on daily basis.

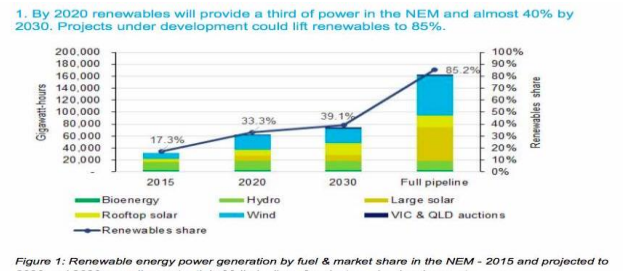


Figure 1: Renewable energy power generation by fuel & market share in the NEM - 2015 and projected to 2020 and 2030 as well as potential of full pipeline of projects under development.

India is running one of the largest and most ambitious renewable capacity expansion programs in the world. In 2019 at UN climate summit, India announced that it will be more than doubling its renewable energy target from 175GW by 2022 to 450GW of renewable energy by the same year.[11] Newer renewable electricity sources are projected to grow massively by nearer term 2022 targets, including a more than doubling of India's large wind power capacity and an almost 15 fold increase in solar power from April 2016 levels.

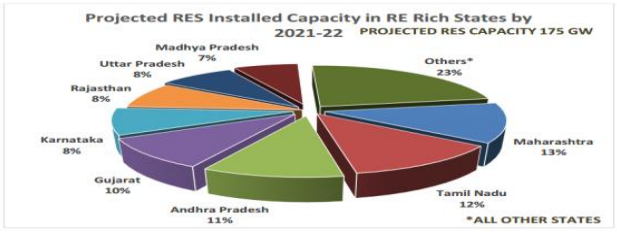


Fig. 2 Renewable Energy installed capacity State wise

These targets would place India among the world leaders in renewable energy use and place India at the centre of its "Sunshine Countries" International Solar Alliance project promoting the growth and development of solar power internationally to over 120 countries.Energy plays a vital role in the economic development of all countries. India ranks second position in terms of population that accounts to 18% of world's overall population. The increase in standard of living and population in India makes India to rank fourth place in consumption of energy in the globe. As fossil fuels are depleting and creating more pollution causing global warming, and also since energy demand is increasing day by day, energy production from renewable energy

resources becomes the best solution in present condition as renewable energy resources are not exhaustible, clean, and green energy.

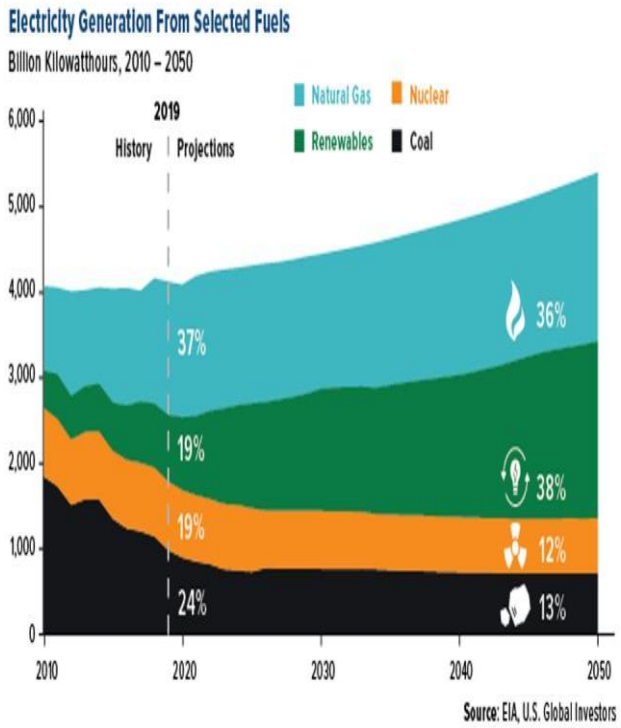


Fig. 3 Electricity generation from selected fuel

III. STATE WISE TARGET OF RENEWABLE ENERGY IN INDIA

The state-wise breakup of the 175 GW target as expected by MNRE is shown in Figure 6, while the state-wise and year-wise breakup of the 40 GW rooftop target is shown in. Just five states (Maharashtra, Tamil Nadu, Andhra Pradesh, Gujarat, and Karnataka) are expected to contribute 94 GW (54% of the total), while the top ten states (including Rajasthan, Uttar Pradesh, Madhya Pradesh, West Bengal, and Punjab) make up 145 GW (83% of the total).

The bulk of the capacity is expected to be concentrated in the southern and western regions which are not only areas with higher consumption but also with better renewable energy resources. The state-wise rooftop solar allocation is not as concentrated as the 175 GW allocation. The top five states (Maharashtra, Uttar Pradesh, Tamil Nadu, Gujarat, and Karnataka) are expected to contribute 18 GW (45% of the total), while the top ten states (including Rajasthan, Madhya Pradesh, West Bengal, Tamil Nadu, and Andhra Pradesh) make up 28.6 GW (72% of the total).

States wise and Year wise targets proposed for 40,000 MWp Grid Connected Solar Rooftop Projects.

States wise and Year wise targets proposed for 40,000 MWp Grid Connected Solar Rooftop Projects

Sl. No.	States	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	Total
1	Andhra Pradesh	10	240	250	300	350	400	450	2000
2	Bihar	5	120	125	150	175	200	225	1000
3	Chhattisgarh	4	84	88	104	120	140	160	700
4	Delhi	5	132	138	165	190	220	250	1100
5	Gujarat	15	385	400	480	560	640	720	3200
6	Haryana	5	200	200	235	280	320	360	1600
7	Himachal Pradesh	2	38	40	48	56	64	72	320
8	Jammu & Kashmir	2	54	55	74	80	90	95	450
9	Jharkhand	4	96	100	120	140	160	180	800
10	Karnataka	10	275	290	344	403	460	518	2300
11	Kerala	4	96	100	120	140	160	180	800
12	Madhya Pradesh	10	265	275	330	385	440	495	2200
13	Maharashtra	20	565	588	704	823	940	1060	4700
14	Orissa	5	120	125	150	175	200	225	1000
15	Punjab	10	240	250	300	350	400	450	2000
16	Rajasthan	10	275	288	344	403	460	520	2300
17	Tamil Nadu	15	420	438	524	613	700	790	3500
18	Telangana	10	240	250	300	350	400	450	2000
19	Uttarakhand	2	42	44	52	60	70	80	350
20	Uttar Pradesh	20	510	538	650	752	860	970	4300
21	West Bengal	10	252	263	315	370	420	470	2100
22	Arunachal Pradesh	2	5	5	8	10	10	10	50
23	Assam	4	30	30	38	42	50	56	250
24	Manipur	4	3	6	8	9	10	10	50
25	Meghalaya	1	6	6	8	9	10	10	50
26	Mizoram	1	6	6	8	9	10	10	50
27	Nagaland	1	6	6	8	9	10	10	50
28	Sikkim	1	6	6	8	9	10	10	50
29	Tripura	1	6	6	8	9	10	10	50
30	Chandigarh	1	12	12	14	18	20	23	100
31	Goa	1	20	20	22	23	30	34	150
32	Dadra & Nagar Haveli	1	24	25	30	35	40	45	200
33	Daman & Diu	1	12	12	14	18	20	23	100
34	Puducherry	1	12	12	14	18	20	23	100
35	Andaman & Nicobar Islands	1	2	2	2	5	4	4	20
36	Lakshadweep	1	1	1	1	2	2	2	10
	Total	200	4800	5000	6000	7000	8000	9000	40000

Fig. 4 state wise and year wise target of Grid connected solar Rooftop projects

IV. ENERGY CONSUMPTION IN INDIA

India needs to reform its tariff regime to reduce dependence on discoms and bring new electricity procurement models to boost consumption of renewables by commercial and industrial (C&I) consumers, according to an industry expert. As per a report by WWF-India, C&I consumers account for 51 per cent of the total electricity consumption in India, which is equivalent to 1,130 TWh per annum. "Consumption of renewable power cannot only make C&I consumers cost competitive and spur macro-economic growth, but also play a significant role in reducing India's carbon emissions," As part of a stronger Climate Action Plan, India has committed to increase renewable power capacity target from 175 GW in 2022 to 450 GW by 2030.

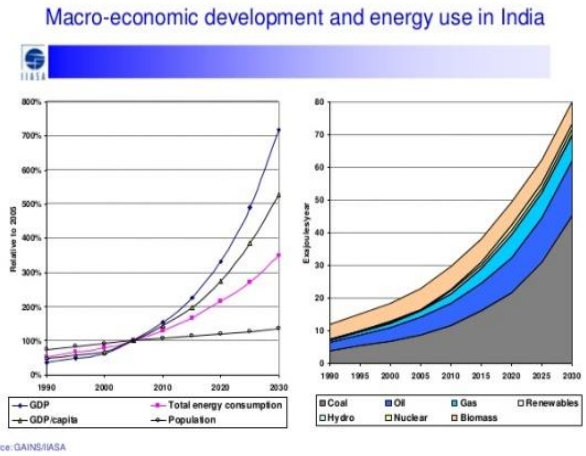


Fig. 5 Macro-economic development and energy use in India

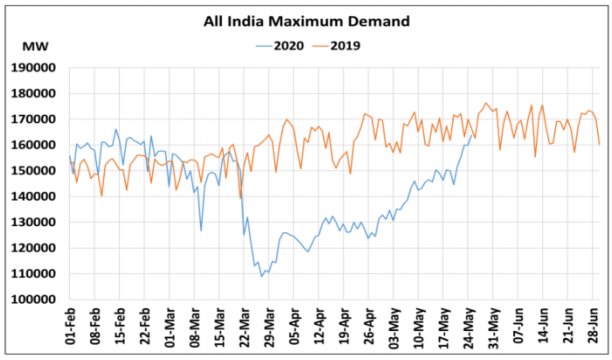


Fig. 6 All India Maximum energy demand Date wise

Greater adoption of clean energy by C&I consumers is critical for meeting these national renewable energy and climate change commitments. The report also said captive coal-fired capacity in the country is estimated at 52,933 MW and combined share of renewable power in their consumption mix is likely to be only 10.5 per cent. .. With renewable power costs falling rapidly, C&I consumers have a very strong financial incentive to switch to clean energy. They can not only make attractive savings of around 30-60 per cent on grid power, but also reduce carbon emissions and comply with renewable purchase obligations, the report suggests. Currently, the avenues available to C&I consumers to procure renewable power are limited to rooftop solar installations, open access solar and wind power, and RECs (renewable energy certificates).

Table 1 Energy consumption (Gwh)

Date	Energy Consumption (GWh)					
	Northern Region	Western Region	Southern Region	Eastern Region	North-Eastern Region	All India
19-May-20	1065	1050	837	405	48	3405
20-May-20	1087	1052	898	294	45	3375
21-May-20	1109	1076	932	269	37	3423
22-May-20	1164	1087	954	325	39	3569
23-May-20	1192	1095	959	369	41	3656
24-May-20	1201	1100	938	396	39	3675
25-May-20	**1229**	**1125**	**960**	**390**	**37**	**3740**

However, even these options are not freely available because of various policy and market constraints. With the growing C&I renewable power market worldwide, many new alternative procurement options have opened up. Virtual power purchase agreements, green tariffs, internationally tradable RECs (IRECs have already been successfully tried and tested in many countries.

New Delhi: With the northern region of the country grappling with an intense heat wave, the peak power demand on 25 May crossed the 163 Gigawatt (GW) mark, registering the highest jump in the peak demand so far in May. Earlier the country recorded the highest peak demand of 160 GW on 23 May

V. TYPES OF RENEWABLE ENERGY SORCE

1. Hydro power plant

India is the 7th largest producer of hydroelectric power in the world. As of 31 March 2020, India's installed utility-scale hydroelectric capacity was 45,699 MW, or 12.35% of its total utility power generation capacity.[2] Additional smaller hydroelectric power units with a total capacity of 4,380 MW (1.3% of its total utility power generation capacity) have been installed.[21][2] Small hydropower, defined to be generated at facilities with nameplate capacities up to 25 MW, comes under the ambit of the Ministry of New and Renewable energy (MNRE); whilst large hydro, defined as above 25 MW, comes under the ambit of Ministry of Power.[22][23]

2. Wind Power

Fig.7 The largest wind farm of india in Muppandal ,Tamil Nadu.

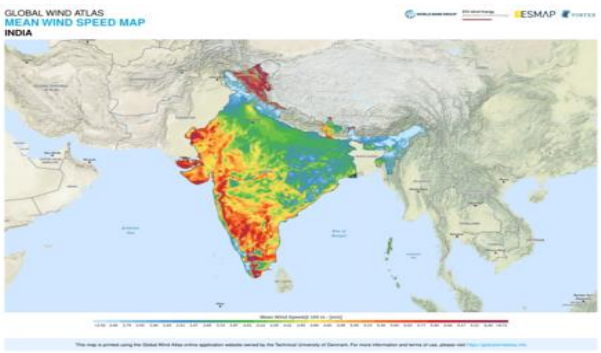


Fig.8 Mean wind speed in India.[24]

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the US, domestic policy support for wind power has led India to become the country with the fourth largest installed wind power capacity in the world.[25]

As of 30 June 2018 the installed capacity of wind power in India was 34,293 MW,[9] mainly spread across Tamil Nadu (7,269.50 MW), Maharashtra (4,100.40 MW), Gujarat (3,454.30 MW), Rajasthan (2,784.90 MW), Karnataka (2,318.20 MW), Andhra Pradesh (746.20 MW)

and Madhya Pradesh (423.40 MW)[26] Wind power accounts for 10% of India's total installed power capacity.[27] India has set an ambitious target to generate 60,000 MW of electricity from wind power by 2022.[28] The Indian Government's Ministry of New and Renewable Energy announced a new wind-solar hybrid policy in May 2018.[29] This means that the same piece of land will be used to house both wind farms and solar panels.

3: Solar Power

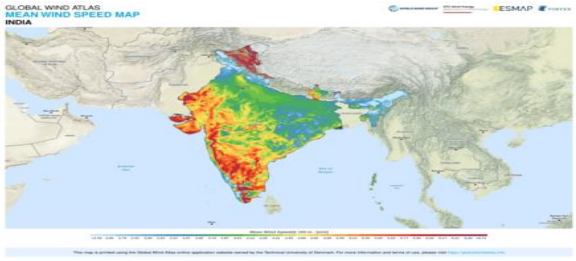


Fig.9 Global Horizontal Irradiation in India

India is densely populated and has high solar insolation, an ideal combination for using solar power in India. Announced in November 2009, the Government of India proposed to launch its Jawaharlal Nehru National Solar Mission under the National Action Plan on Climate Change. The program was inaugurated[39] by former Prime Minister Manmohan Singh on 11 January 2010[40] with a target of 20GW grid capacity by 2022 as well as 2GW off-grid installations, this target was later increased to 100 GW by the same date under the Narendra Modi government in the 2015 Union budget of India.

[41] Achieving this National Solar Mission target would establish India in its ambition to be a global leader in solar power generation.[42] The Mission aims to achieve grid parity (electricity delivered at the same cost and quality as that delivered on the grid) by 2022.[40] The National Solar Mission is also promoted and known by its more colloquial name of "Solar India". The earlier objectives of the mission were to install 1,000 MW of power by 2013 and cover 20×106 m2 (220×106 sq ft) with collectors by the end of the final phase of the mission in 2022.[43]

On 30 November 2015, the Prime Minister of India Narendra Modi and the President of France Francois Hollande launched the International Solar Alliance. The ISA is an alliance of 121 solar rich countries lying partially or fully between the Tropic of Cancer and the Tropic of Capricorn, several countries outside of this area are also involved with the organization. The ISA aims to promote and develop solar power amongst its members and has the objective of mobilising $1 trillion of investment by 2030.[44] As of August, 2019, the Indian Oil Cooperation stated that it wants to invest 250 Billion Rupee in renewable energy projects.[45]

Much of the country does not have an electrical grid, so one of the first applications of solar power was for water pumping, to begin replacing India's four to five million diesel powered water pumps, each consuming about 3.5 kilowatts, and off-grid lighting. Some large projects have been proposed, and a 35,000 km2 (14,000 sq mi) area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 gigawatts. Solar power in India has been growing at a rate of 113% yoy[46] and now dropped to around ₹4.34 (6.1¢ US) per kWh, which is around 18% lower than the average price for electricity generated by coal-fired plants.[47][48]

As part of India's ambitious solar programme the central government has set up a US$350 million fund and the Yes Bank will loan US$5 billion to finance solar projects (c. January 2018).[13] India is also the home to the world's first and only 100% solar-powered airport, located at Cochin, Kerala.[49] India also has a wholly 100% solar-powered railway station in Guwhati, Assam. India's first and the largest floating solar power plant was constructed at Banasura Sagar reservoir in Wayanad, Kerala.[50]

The Indian Solar Loan Programme, supported by the United Nations Environment Programme has won the prestigious Energy Globe World award for Sustainability for helping to establish a consumer financing program for solar home power systems. Over three years more than 16,000 solar home branches, particularly in rural areas of South India where the electricity grid does not yet extend.[51][52]

Launched in 2003, the Indian Solar Loan Programme was a four-year partnership between UNEP, the UNEP Risoe Centre, and two of India's largest banks, the Canara Bank and Syndicate Bank.[52]

4. Biomass

India is an ideal environment for Biomass production given its tropical location and abundant sunshine and rains. The country's vast agricultural potential provides huge agro-residues which can be used to meet energy needs, both in heat and power applications.[53] According to IREDA "Biomass is capable of supplementing the coal to the tune of about 260 million tonnes", "saving of about Rs. 250 billion, every year."[54] It is estimated that the potential for biomass energy in India includes 16,000 MW from biomass energy and a further 3,500 MW from bagasse cogeneration.[54] Biomass materials that can be used for power generation include bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells and sawdust.

VI. ENVIRONMENTAL SUSTAINABILITY OF RENEWABLE ENERGY AND CLIMATE CHANGE

To sustain economic growth and raise living standards, energy shortages could be met by increasing supplies. But there are two other important considerations: environmental sustainability and social development.

The current pattern of economic growth has caused serious environmental damage – polluting the air, creating large quantities of waste, degrading biological systems and accelerating climate change – with many of these effects coming from the energy sector. At the same time, it is also vital to consider the impact on social development. The lack of access to energy services aggravates many social concerns, including poverty, illhealth, unemployment and inequity. In modern economic sectors one of the main sources of energy is oil. Although the world's largest oil consumer is still the United States, four Asian countries are not far behind; China comes second, Japan third, India fourth and the Republic of Korea sixth [17]. Natural gas is also increasingly important: its fuel efficiency.

makes it an attractive choice for new power generating plants and for the industrial sector. Other environmental concerns include water pollution and the disposal of waste, particularly nuclear waste. In the rural areas one worry is the overexploitation of environmentally sensitive areas. Many people in rural areas rely on biomass fuels for cooking, heating and lighting. Overuse of these can lead to degradation of watersheds, and loss of biodiversity and habitats. About 70% of total green house gas (GHG)emissions are related to energy,mainly from the combustion of fossil fuels for heat, electricity generation and transport. Countries have many options for reducing GHG emissions-at minimal, zero or even net negative costs. These include energy conservation along with increases in effciency, better energy management, cleaner production and consumption, and changes in lifestyles. Renewable and other more effcient technologies would also help mitigate climate change. Overall, countries can foster science-based decision-making that creates incentives for cleaner and more energy-efficient economic activities while increasing people's access to modern energy services.

1. Climatic Changes

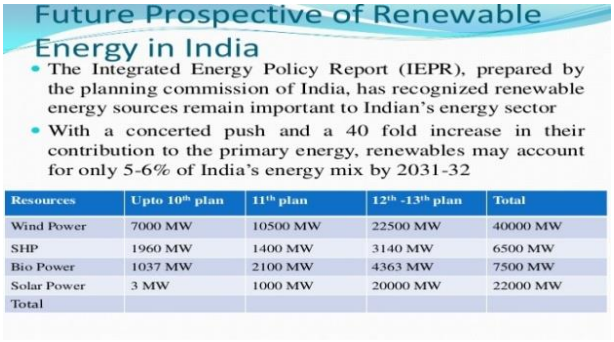
Climatic changes, as a result of global warming caused by greenhouse gases, mainly carbon dioxide (CO_2) produced during the burning of fossil fuels, have been causing significant changes in the ecosystems and leading to nearly 150,000 additional deaths every year [2]. This rise is mainly caused by the unsustainable use of fossil fuels and the changes in the use of the land [18].

2. Clean Development Mechanism

The clean development mechanism(CDM)of the Kyoto Protocol has been set up to assist developing countries in achieving sustainable development by promoting greenhouse gas emission reduction projects, that generate emission credits (certified emissions reductions, CERs) for industrialized countries [19].A number of countries in the region are taking advantage of the CDM. This is a provision of the Kyoto Protocol which was devised originally as a bilateral mechanism through which entities in industrialized countries could gain certified emission reductions (CERs) by investing in clean technologies in developing countries. For the recipient developing countries, this can boost returns on projects by up to 12% for wind, hydro and geothermal projects and by 15–17% for biomass and municipal waste projects (UNEP). Indian enterprises have already committed investment to generate more than 379 million CERs.

VII. FUTURE PROSPECTS OF RENEWABLE ENERGY IN INDIA:

With right investments in green technologies, we can say that India is well positioned to achieve the ambitious renewable energy targets. The pursuit towards cleaner energy will play a key role in supporting country's transition to a full sustainable energy system.



Resources	Upto 10th plan	11th plan	12th -13th plan	Total
Wind Power	7000 MW	10500 MW	22500 MW	40000 MW
SHP	1960 MW	1400 MW	3140 MW	6500 MW
Bio Power	1037 MW	2100 MW	4363 MW	7500 MW
Solar Power	3 MW	1000 MW	20000 MW	22000 MW
Total				

Fig.10 Future prospective of renewable energy in India

It is not a hidden fact that India is the world's fourth-largest carbon emitter with its total population of 1.3 billion people with power sector contributing majorly to the same. However, in the recent years, India has made significant progress in field of renewable energy. Global climate change concerns have pushed the Government to develop a detailed plan for clean and sustainable power for all.

As per the research by University of Technology (LUT) in Finland, owning to an abundance of renewable resources, there is a great potential for India to move into a fully renewable electricity system by 2050. This is possible if we can employ sophisticated technologies. Renewable energy's development in India looks bright as around 293 global and domestic companies have committed to generate 266 GW of solar, wind, mini hydel

and biomass-based power in India over the next decade. This would entail an investment of $310 billion - $350 billion (Euros 27 billion to Euros 30 billion).

The International Finance Corporation, the investment arm of the World Bank Group, is planning to invest about $6 billion (Euros 5 billion) by 2022 in several sustainable and renewable energy programs in India. With the investment potential of INR 15 trillion (Euros 187 billion) over the next four to five years in Indian power sector indicates immense opportunities in power generation, distribution, transmission and equipment. Further, renewable energy storage market in India is also expected to witness robust growth, over the next decade, once the cost of storage declines, which is likely to happen because of sheer volume growth through the electric vehicle route.
To conclude, we can say that India has plenty of renewable energy to bridge the gap between demand and supply so we must persistently put in efforts to harness various forms of renewable energy sources with the use of newer technologies to form a clean and safe place for our coming generations
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VIII. MAJOR ACHIEVEMENTS

India's major achievements on renewable energy development can be summarized as follows:
Over 4200 MW grid power from wind, small hydro, biomass and solar energy. 3600 remote villages/hamlets, including those in Sunderbans, Bastar, Ladakh and the North East electrified through solar energy. Largest solar–steam cooking system for 15,000 persons/day set up at Tirupati Tirumala Devasthanam. 7 lakh square meter collector area solar water heating systems installed. 3.5 million biogas plants installed for cooking and lighting applications.

35 million improved wood stoves in rural homes. Integrated Rural Energy Program implemented in 860 blocks. 30 MW capacity Solar Photovoltaic products exported to various developed and developing countries. 280 Energy Parks set-up in educational institutions for demonstration of renewable energy systems and devices. Rs.25, 000 million direct subsidies given so far to beneficiaries/ users of renewable energy systems and devices, including subsidy for grid connected renewable power projects. Rs. 32,000 million loan provided so far by Indian Renewable Energy Development Agency Limited for 1600 renewable energy project. Centre for Wind Energy Technology set up as a scientific and industrial research organization for wind resource assessment, equipment certification and

IX. CONCLUSIONS

Energy security, economic growth and environment protection are the national energy policy drivers of any country of the world. The need to boost the efforts for further development and promotion of renewable energy sources has been felt world over in light of high prices of crude oil. A critical part of the solution will lie in promoting renewable energy technologies as a way to address concerns about energy security, economic growth in the face of rising energy prices, competitiveness, health costs and environmental degradation. According to NAPCC other sources of renewable energy would be promoted. Specic action points that have been mentioned include promoting deployment, innovation and basic research in renewable energy technologies, resolving the barriers to development and commercial deployment of biomass, hydropower, solar and wind technologies, promoting straight (direct) biomass combustion and biomass gasication technologies, promoting the development and manufacture of small wind electric generators, and enhancing the regulatory/tariff regime in order to main stream renewable energy sources in the national power system.

Accordingly, increased focus is being laid on the deployment of renewable power that is likely to account for around 5% in the electricity-mix by 2032. Alternate fuels, essentially bio-fuels, are proposed to be progressively used for blending with diesel and petrol, mainly for transport applications. Finally, renewable energy provides enormous benets and can contribute signifcantly in the national energy mix at least economic, environmental and social costs and it is expected that the share of renewable energy in the total generation capacity will increase in future.

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