AN INVESTIGATION ANALYSIS OF GROWTH IMPACT ON RENEWABLE POWER GENERATION IN INDIA

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Abstract:Most of the commercial energy demand in India is met largely by imported fossil fuels. In 2013, India was the 4th biggest consumer and net importer of crude and petroleum products in the world (Barpatragohain, 2015). As the country is essentially dependent on energy import, any shortfall due to unforeseen geopolitical situation may cause acute energy scarcities which will consecutively impede the industrial growth and economic progress. In order to achieve energy independence, the dependency on imported oil has to be reduced by developing alternate energy sources. If renewable power systems deliver such impressive benefits, but still we produce only 20-25% percent of national electricity generation in the India. The share of renewable energy sources, primarily wind and solar is poised to growth significantly power system. The Indian government has set a target of 175 GW of installed renewable capacity by 2022. Including 60GW of wind and 100 GW of Solar, up from an installed capacity of 29 GW wind and 9 GW solar at the beginning of 2017. Whether the target is achievable or not will be determined by market and policy led forces. However a key question that arises is what would be the operational impact of meeting these targets and what actions can be taken for effective integration of renewables. At low levels, integrating solar and wind energy into grid can be achieved relatively easily. But at higher levels, wind and solar generation can present some challenges to grid operations because the additional variability and uncertainty it brings to the power system. This thesis work leaves policymakers with a lot of thinking to do regarding the viability of other alternatives in long-term power planning, and underscores the need for path-breaking R & D in the sector.

***IndexTerms*–Renewable Power Generation, Wind Power, Solar Power, Waste to Energy.**

I. INTRODUCTION

Energy being a strategic commodity plays a significant role in economic development of a country. Energy systems in India have evolved over last six decades along with country's economic development, supporting the aspiration of 1.2 billion people, within the framework of democratic polity, globally integrated economy and environmentally sensitive regime. Ever increasing demand of energy has posed tremendous pressure on its limited resources and has necessitated optimum use of its resources. India pursued a reformed development agenda since 1991. Significant effort has gone into improving energy availability, as support to country's development initiatives.

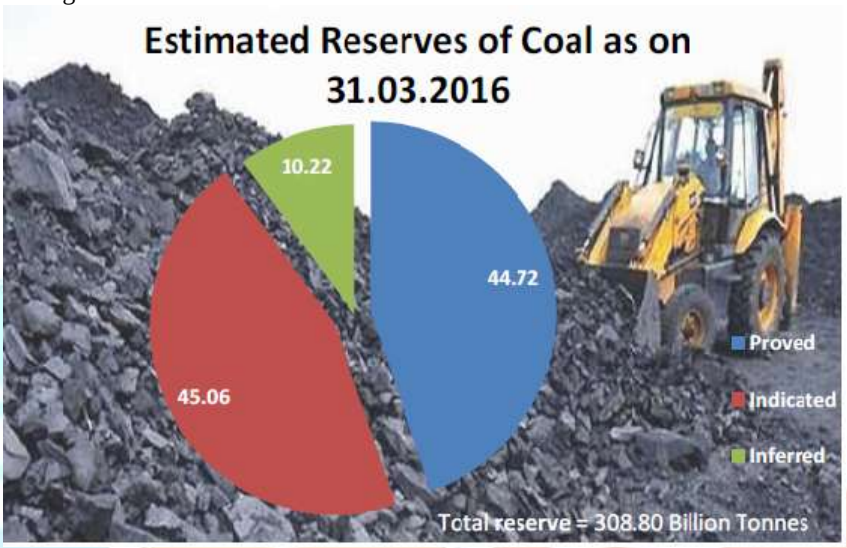
India has set out on the path of harnessing renewable energy (RE) sources than never before. The reasons are many and are not hard to find within the chronic shortage of power, matters of energy security and environmental concerns. The country's energy strategy is moving strongly in favor of renewable energy (RE) technologies. This strategy has made India a leader in a number of renewable energy technology (RET) applications such as grid connected wind energy generation, decentralized solar PV for rural applications, decentralized distributed generation etc. India has now has set itself very aggressive targets for RE capacity addition. The 11th Five Year Plan (FYP) (FY 2012-17) envisages the addition of 14,050 MW of additional capacity, which means adding, in 5 years, more capacity than what India has added since independence. However, RE capacity addition and development of the sector suffers on account of a number of constraints, overlaps and gaps prevalent in the current policy and regulatory environment. It is becoming clear that the policy and regulatory framework introduced so far has been appropriate only for accelerating the early growth of the sector from a small base and helping in mainstreaming RE. However this policy and regulatory environment has now (with changing market conditions and imperatives) become outmoded for the sector. Though the Ministry of New and Renewable Energy (MNRE) has been taking proactive steps for improving this environment, its initiatives have been able to address specific problems and constraints, and have not been successful in helping the RE sector as a whole in India to leap frog ahead. There is therefore a need to review the existing environment for development of RE and propose a new approach to the development of this sector. With this objective, this paper examines the current status of RE development in India and the existing environment for such development. It examines the barriers to further development as well as gaps constraining investments in this sector of renewable energy. It then makes recommendations towards removing such barriers and adopting new mechanisms for the promotion of RE. In sum, the paper identifies the issues that have to be addressed in order to achieve a widespread use of RE, so that determined and practical steps can be taken to increase substantially their application. RE technologies (RETs) in India can be divided into two categories: (i) near commercial and commercial technologies such as wind, small hydro power (SHP), solar PV, biomass and co-generation (cogen) that have matured and are being deployed or are close to deployment, and (ii) emerging technologies such as solar thermal and biofuels that will need time to mature. The latter will also

have to undergo pilots before commercial deployment. This paper focuses on the RETs that fall in the first category. The paper also restricts itself to grid-connected RE.

2. RESERVES AND POTENTIAL FOR GENERATION

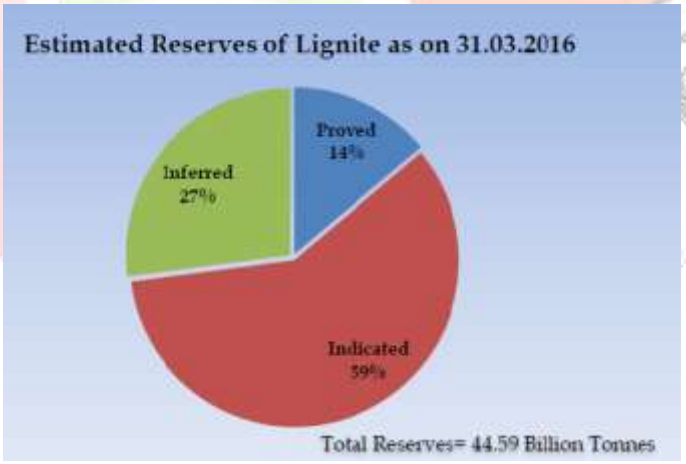
2.1 Coal and Lignite

Coal deposits are mainly confined to eastern and south central parts of the country. The states of Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Telangana and Maharashtra account for 98.58 % of the total coal reserves in the country. The State of Jharkhand had the maximum share (26.29%) in the overall reserves of coal in the country as on 31st March 2016 followed by the State of Odisha (24.58%). As on 31.03.16, the estimated reserves of coal were 308.80 billion tonnes, an addition of 2.20 billion tonnes over the last year. There has been an increase of 0.7% in the estimated coal reserves during the year 2015-16 with Chhattisgarh accounting for the maximum increase of 2.05%.



Graph 2.1 Estimated Reserves of Coal Data

The estimated total reserves of lignite as on 31.03.16 was 44.59 billion Tonnes against 44.12 billion tonnes on 31.03.15.



Graph 2.2 Estimated Reserves of Ignite

2.2 Installed generating capacity of electricity

The total installed capacity for electricity generation in the country has increased from 154664 MW as on 31.03.2007 to 350367 MW as on 31.03.2016, registering a compound annual growth rate (CAGR) of 8.52%

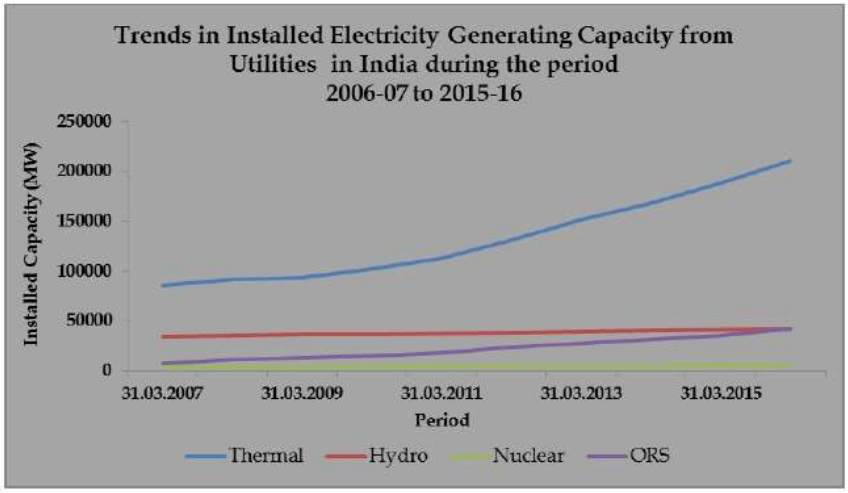
Electricity generation capacity increased by 10.74% to 33987 MW in 2015-16.

The highest rate of annual growth from 2014-15 to 2015-16 in installed capacity was for Other Renewable sources (ORS) (19.25%) followed by Thermal Power (10.91%).

The total Installed capacity of power utilities in the country increased from 132329 MW in 31.3.2007 to 302088 MW as on 31.3.2016, with a CAGR of 8.60% over the period.

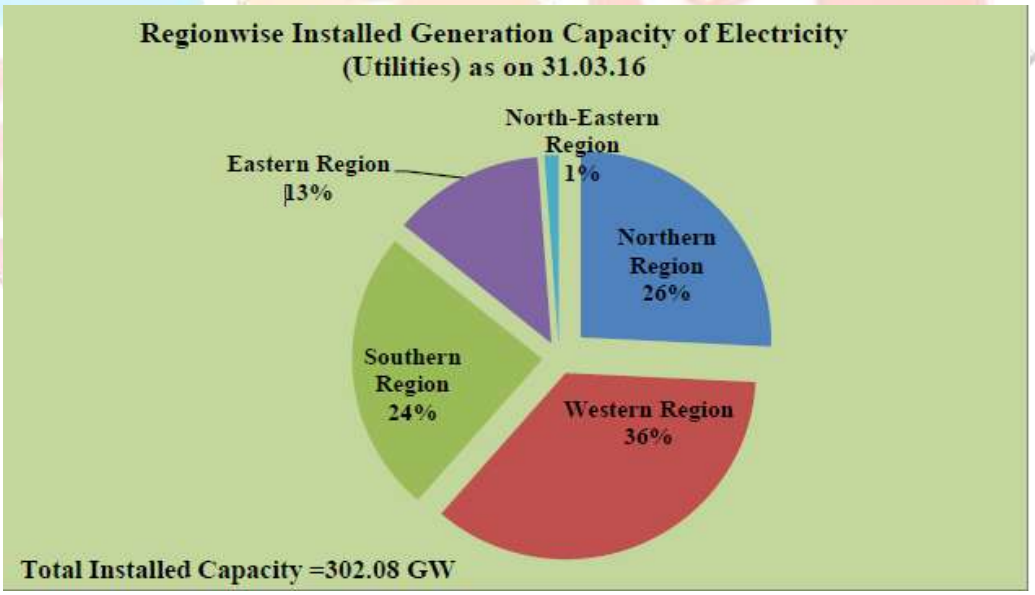
At the end of March 2016, thermal power plants accounted for an overwhelming 73.50% of the total installed capacity in the country, with an installed capacity of 257528 MW. Other renewable Sources (excluding hydro) come next with an installed capacity of 44217 MW, accounting for 12.62% of the total installed Capacity. The share of Hydro and Nuclear energy was only 12.23% and 1.65% of total installed capacity.

Non-utilities accounted for 13.78% (48279 MW) of the total installed electricity generation capacity.



Graph 2.3 Electricity Generation Capacity Chart

The geographical distribution of Installed generating capacity of electricity as on 31.03.16 (Table 2.4) indicates that Western Region (both central and state sector) accounted for the highest share (36%) followed by Northern Region (26%), Southern Region (24%), Eastern Region (13%) and North Eastern Region (1%).



Graph 2.4 Region wise Electricity Generation

Region wise growth in the installed capacity during 2015-16 reveals that Southern Region registered the highest annual growth of about 17.03%, followed by Northern Region (15.45%), Western Region (6.71%), Eastern Region (6.03%) and North Eastern Region (5.61%).

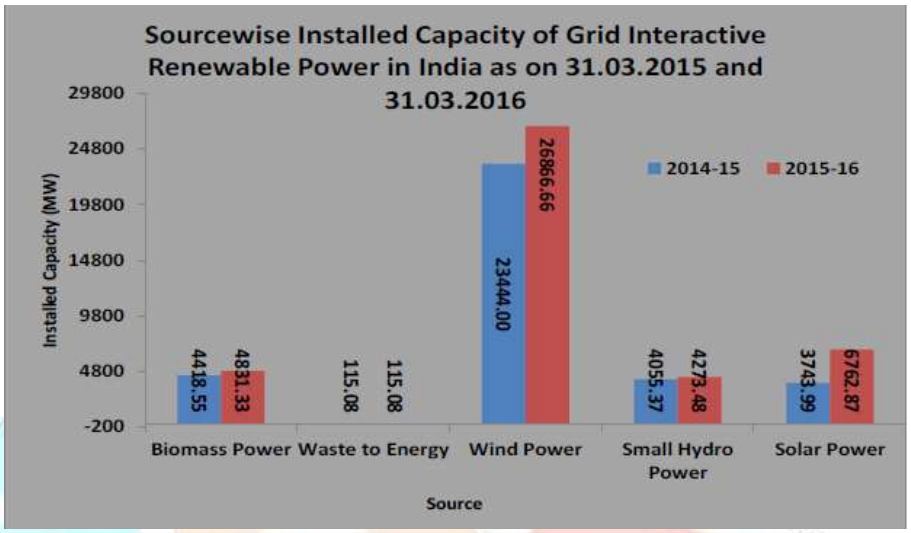
Among all the states Telangana registered highest annual growth (97.01%) in the installed capacity followed by Nagaland (70.29%) and Sikkim (58.29%).

2.3 Grid Interactive Renewable Power

The total installed capacity of grid interactive renewable power, which was 35776.96 MW as on 31.03.2015, had gone up to 42849.38 MW as on 31.03.2016 indicating growth of 19.77% during the period (Table 2.5).

Out of the total installed generation capacity of renewable power as on 31-03-2016, Wind power accounted for about 62.7%, followed by Solar power (15.78%) and Biomass power (11.46%).
Tamil Nadu had the highest installed capacity of grid connected renewable power (9448.68 MW) followed by Maharashtra (6613.28 MW) and Rajasthan (5396.03 MW), mainly on account of wind power.

As on 31.03.2016, out of total number of Biogas plants installed (48.35 lakh) , maximum number of plants installed were in Maharashtra (8.71 lakh) followed by Andhra Pradesh (5.32 lakh), Karnataka (4.79 lakh), Uttar Pradesh (4.39 lakh) and Gujarat (4.30 lakh).



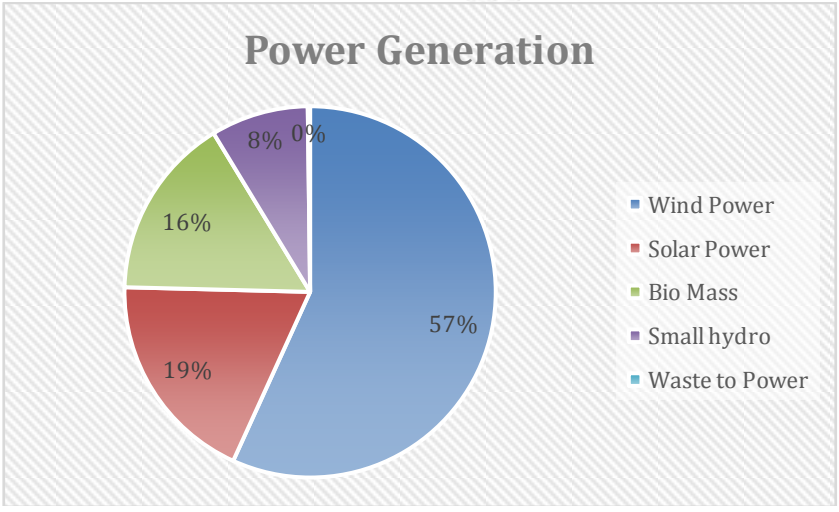
Graph 2.5 Source Wise Installed Capacity

As on 31.03.2016, a total of 5, 86,065 villages were electrified accounting for 98.1% of the total villages in the country.

2.4Installed grid interactive renewable power capacity (excluding large hydropower) in India as of 31 March 2017 (RES MNRE)

Source	Total Installed Capacity (MW)	2022 Target (MW)
Wind power	32279.97	60,000
Waste to power	114.08	10,000
Solar power	12288.83	100,000
Small hydro power	4379.85	5000
Bio mass power	8182	10,000
Total	**57,244.23**	**1,75,000**

Table 1 Installed grid interactive renewable power capacity



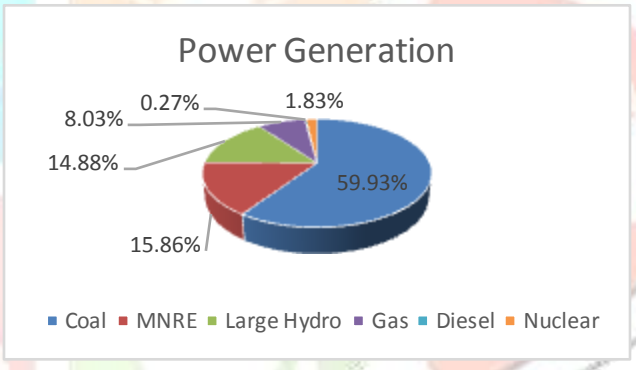
Graph 2.6 Power Generation Percentages

The target is given for "bio-power" which includes biomass power and waste to power generation. The figures above refer to newer and fast developing renewable energy sources and are managed by the Ministry for New and Renewable Energy (MNRE). In addition as of 31 December 2016 India had 50,017.97 MW of installed large hydro capacity, which comes under the ambit of Ministry of Power. In terms of meeting its ambitious 2022 targets, as of 31 March 2017, wind power was more than halfway towards its goal, whilst solar power was below 13% of its highly ambitious target, although expansion is expected to be dramatic in the near future. Bio energy was at just above 80% mark whilst small hydro power was already 85% of the way to meet its target. Overall India was at 33% towards meeting its 2022 renewable installed power capacity target of 175 GW. The total breakdown of installed grid connected capacity from all sources including large hydro was as follows

Source	Installed Capacity	Total %
Coal	189,047.88	59.93%
Res MNRE	50,018.00	15.86%
Large Hydro	44,413.43	14.85%
Gas	25,329.38	8.03%
Diesel	837.63	0.27%
Nuclear	5,780.00	1.83%
Total	3,15,426.32	100%

Table 2 Installed grid power capacity from all sources in India as of 28 February 2017

The first figure at the top of the table refers to the fast growing renewable energy sources under the responsibility of the Ministry for New and Renewable Energy and slightly exceeded the installed capacity of large hydro installations. This figure is targeted to reach 175 GW by 2022. Coal power currently represents the largest share of installed capacity at just under 186 GW. Total installed capacity as of 30 April 2016, for grid connected power in India stood at a little under 303 GW.



Graph 2.7 Total Power Generation Percentages

3. WIND POWER

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.

As of 28 February 2017 the installed capacity of wind power in India was 29151.29 MW, 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)[9] Wind power accounts for 14% of India's total installed power capacity India has set an ambitious target to generate 60,000 MW of electricity from wind power by 2022 .

Wind Farm	Producer	State	Capacity (MW)
Muppandal wind farm	Muppandal Wind	Tamil Nadu	1,500
Jaisalmer Wind Park	Suzlon Energy	Rajasthan	1,275
Brahmanvel windfarm	Parakh Agro Industries	Maharashtra	528
Dhalgaon windfarm	Gadre Marine Exports	Maharashtra	278
Chakala windfarm	Suzlon Energy	Maharashtra	217
Vankusawade Wind Park	Suzlon Energy	Maharashtra	189
Vaspet Windfarm	ReNew Power	Maharashtra	144

Table 3 Largest Wind Farms in India

4. Solar power

India is densely populated and has high solar insolation, an ideal combination for using solar power in India. Much of the country does not have an electrical grid, so one of the first applications of solar power has been 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 km^2 (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 and now dropped to around □ 4.34(6.8¢ US) per kWh, which is around 18% lower than the average price for electricity generated by coal-fired plants.

The Indian Solar Loan Programme, supported by the United Nations Environment Programme has won the prestigious Globe World award for Sustainability for helping to establish a consumer financing program for solar home power systems. Over the span of three years more than 16,000 solar home systems have been financed through 2,000 bank branches, particularly in rural areas of South India where the electricity grid does not yet extend.

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.

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 with plans to generate 1,000 MW of power by 2013 and up to 20,000 MW grid-based solar power, 2,000 MW of off-grid solar power and cover 20×10^6 m^2 (220×10^6 sq ft) with collectors by the end of the final phase of the mission in 2020. The Mission aims to achieve grid parity (electricity delivered at the same cost and quality as that delivered on the grid) by 2020. Achieving this target would establish India as a global leader in solar power generation.

India is also the home to the world's first and only 100% solar powered airport, located at Cochin, Kerala.

Solar power in India is a fast developing industry. As of September, 2017 the country's solar grid had a cumulative capacity of 16.20 GW. India quadrupled its solar-generation capacity from 2,650 MW on 26 May 2014 to 12,289 MW on 31 March 2017. The country added 3.01 GW of solar capacity in 2015-2016 and 5.525 GW in 2016-2017, the highest of any year, with the average current price of solar electricity dropping to 18% below the average price of its coal-fired counterpart.

In January 2015 the Indian government expanded its solar plans, targeting US$100 billion in investment and 100 GW of solar capacity (including 40 GW from rooftop solar) by 2022. India's initiative of 100 GW of solar energy by 2022 is an ambitious target, since the world's installed solar-power capacity in 2014 was 181 GW. The improvements in solar thermal storage power technology in recent years has made this task achievable as the cheaper solar power need not depend on costly and polluting coal/gas fired power generation for ensuring stable grid operation.

In addition to its large-scale grid-connected solar PV initiative, India is developing off-grid solar power for local energy needs. The country has a poor rural electrification rate; in 2015 only 55 percent of all rural households had access to electricity, and 85 percent of rural households depended on solid fuel for cooking. Solar products have increasingly helped to meet rural needs; by the end of 2015 just under one million solar lanterns were sold in the country, reducing the need for kerosene. That year, 118,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national program; just over 1.4 million cookers were distributed in India.

In January 2016, Prime Minister Narendra Modi and French President François Hollande laid the foundation stone for the headquarters of the International Solar Alliance (ISA) in Gwal Pahari, Gurugram. The ISA will focus on promoting and developing solar energy and solar products for countries lying wholly or partially between the Tropic of Cancerand the Tropic of Capricorn. The alliance of over 120 countries was announced at the Paris COP21 climate summit. One hope of the ISA is that wider deployment will reduce production and development costs, facilitating the increased deployment of solar technologies to poor and remote regions.

With about 300 clear and sunny days in a year, the calculated solar energy incidence on India's land area is about 5000 trillion kilowatt-hours (kWh) per year (or 5 EWh/yr). The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India. The daily average solar-power-plant generation capacity in India is 0.20 kWh per m^2 of used land area, equivalent to 1400–1800 peak (rated) capacity operating hours in a year with available, commercially-proven technology.

State	MW as of 31st March 2015	MW as of 31st March 2016	MW as of 31st January 2017	MW as of 31st August 2017
Rajasthan	942.10	1,269.93	1,317.64	2,219
Punjab	185.27	405.06	592.35	
Uttar Pradesh	71.26	143.50	269.26	
Uttarakhand	5.00	41.15	45.10	
Haryana	12.80	15.39	73.27	
Delhi	5.47	14.28	38.78	

Jammu and Kashmir	0.00	1.00	1.00	
Chandigarh	4.50	6.81	16.20	
Himachal Pradesh	0.00	0.20	0.33	
Northern Region			**2,353.93**	
Gujarat	1,000.05	1,119.17	1,159.76	1,384
Maharashtra	360.75	385.76	430.46	
Chhattisgarh	7.60	93.58	135.19	
Madhya Pradesh	558.58	776.37	850.35	1,352
D&N	0.00	0.00	0.60	
Goa	0.00	0.00	0.05	
Daman & Diu	0.00	4.00	4.00	
Southern Region			**2,580.37**	
Tamil Nadu	142.58	1,061.82	1,590.97	1,804
Andhra Pradesh	137.85	572.97	979.65	2,153
Telangana	167.05	527.84	1,073.41	2,792
Kerala	0.03	13.05	15.86	
Karnataka	77.22	145.46	341.93	1,649
Puducherry	0.20	0.20	0.03	
Western Region			**4,001.85**	
Bihar	0.00	5.10	95.91	
Odisha	31.76	66.92	77.64	
Jharkhand	16.00	16.19	17.51	
West Bengal	7.21	7.77	23.07	
Sikkim	0.00	0.00	0.01	
Eastern Region			**214.14**	
Assam	0.00	0.00	11.18	
Tripura	5.00	5.00	5.02	
Arunachal Pradesh	0.03	0.27	0.27	
Mizoram	0.00	0.00	0.01	
Manipur	0.00	0.00	0.10	
Meghalya	0.00	0.00	0.01	
Nagaland	0.00	0.00	0.50	
North Eastern Region			**17.09**	
Andaman & Nicobar	5.10	5.10	5.40	
Lakshadweep	0.75	0.75	0.75	

Others	0.00	58.31	61.70	
Islands and others			**67.85**	
Total	**3,743.97**	**6,762.85**	**9,235.24**	**16,200**

Table 4 State wise Solar Energy Data

5. WASTE TO ENERGY

Every year, about 55 million tonnes of municipal solid waste (MSW) and 38 billion litres of sewage are generated in the urban areas of India. In addition, large quantities of solid and liquid wastes are generated by industries. Waste generation in India is expected to increase rapidly in the future. As more people migrate to urban areas and as incomes increase, consumption levels are likely to rise, as are rates of waste generation. It is estimated that the amount of waste generated in India will increase at a per capita rate of approximately 1-1.33% annually. This has significant impacts on the amount of land that is and will be needed for disposal, economic costs of collecting and transporting waste, and the environmental consequences of increased MSW generation levels.

India has had a long involvement with anaerobic digestion and biogas technologies. Waste water treatment plants in the country have been established which produce renewable energy from sewage gas. However, there is still significant untapped potential. Also wastes from the distillery sector are on some sites converted into biogas to run in a gas engine to generate onsite power.

6. BIOFUELS

In India, a bioethanol program calls for E5 blends throughout most of the country targeting to raise this requirement to E10 and then E20. In 2003, the national government set a 5% mandated blending target for gasoline. Since then, petroleum with an ethanol blend has been developed and used in nine states and four territories: Andhra Pradesh, Daman, Diu, Goa, Dadra, Nagar Haveli, Gujarat, Chandigarh, Haryana, Pondicherry, Karnataka, Maharashtra, Punjab, Tamil Nadu and Uttar Pradesh. In 2005, the country became the world's fourth largest producer of ethanol at 1.6 billion litres and at the same time the world's largest consumer of sugar.

The country aims to replace 20% of the country's diesel requirement with biodiesel in accordance with the National Biodiesel Mission (NBM) by 2012. The NBM has been, and will continue to be, implemented in two stages: First is a demonstration project, which was carried out over the period 2003-2007 aimed at cultivating 400,000 hectares of Jatropha expected to yield about 3.75 tons of oilseed per hectare annually. The project has also demonstrated the viability of other related activities/projects such as seed collection and oil extraction. In addition, the government will build a transesterification plant. Second, a commercialization period which started in 2007 and will proceed until 2012 will continue with Jatropha cultivation. The plan also involves the installation of more transesterification plants that will position India to meet 20 per cent of its diesel needs through biodiesel. High ethanol prices and low availability of sources has compelled the government to amend its 5% blending target with the notification that 5% bioethanol blended petrol shall be supplied in identified areas if (a) the indigenous price of ethanol offered for ethanol blended petrol programme is comparable to that offered by the indigenous ethanol industry for alternative uses, (b) the indigenous delivery price of ethanol offered for the ethanol blended petrol programme at a particular location is comparable to the import parity price of petrol at that location, and (c) there is an adequate supply of ethanol. To encourage investment, there are also tax incentives and excise cuts. At the state level, the Maharashtra government offers waivers of government fee from the 1 percent turnover tax on anhydrous ethanol, INR500 per kiloliter (US$0.048 per gallon) permit fee, 4 percent sales tax, 10 percent surcharge on sales tax, INR1500 per kiloliter (US$0.14 per gallon) import fee, INR300 per kiloliter (US$0.029 per gallon) service charges and 3 percent Octroi, which is a local tax collected on various articles brought into the district for consumption. By 2030, it is expected that India will soon become the world's third largest economy due to its speedy growth. In 2005, the GDP of India was US$0.6 trillion, and it is forecasted to reach US$6.1 trillion by the year 2030 at an annual growth rate of 9%.

The country has about 125 ethanol producers with a total capacity of 1.25 billion liters of ethanol. Most of these ethanol-producers are found in sugar cane growing states like Maharashtra and Uttar Pradesh, which also operate in states such as Tamil Nadu, Andhra Pradesh, Karnataka and Gujarat. India ranks No. 12 in the 2008 Ernst and Young Indices but may rise higher in the ranking once the country is able to coordinate tax incentives between states and state and federal legislation. At present, the country has about 11 factories in the Uttar Pradesh facilities and is expected to produce about 75 million liters of anhydrous alcohol by end-September with 7 units in Tamil Nadu (production capacity of 62.5 million liters of anhydrous alcohol); 8 in Karnataka (anhydrous alcohol production capacity of 66.5 million liters); and 4 units in Andhra Pradesh (capacity of over 40 million liters). Similar steps have also been taken by the cooperative sector units in Maharashtra, Punjab and UP.

7. HYDROELECTRIC POTENTIAL

India's economically exploitable and viable hydroelectric potential is estimated to be 148,701 MW. An additional 6,780 MW from smaller hydro schemes (with capacities of less than 25 MW) is estimated as exploitable.56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have also been identified. In central India, the hydroelectric power potential from

the Godavari, Mahanadi, Nagavali, Vamsadhara and Narmada river basins has not been developed on a major scale due to potential opposition from the tribal population.

The public sector accounts for 92.5% of India's hydroelectric power production. The National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), Satluj Jal Vidyut Nigam (SJVNL), THDC, and NTPC-Hydro are some of the public sector companies producing hydroelectric power in India. The private sector is also expected to grow with the development of hydroelectric energy in the Himalayan mountain ranges and in the northeast of India. Indian companies have also constructed hydropower projects in Bhutan, Nepal, Afghanistan, and other countries.

Bhakra Beas Management Board (BBMB), a state-owned enterprise in north India, has an installed capacity of 2.9 GW. The generation cost after four decades of operation is about 27 paise (0.42¢ US) per kWh. BBMB is a major source of peaking power and black start capability to the northern grid in India and its large reservoirs provide wide operational flexibility. BBMB reservoirs also supply water for the irrigation of 12.5 million acres (51,000 km^2; 19,500 sq. mi) of agricultural land in partner states, enabling the green revolution in the northern India.

8. Different pathways to meeting renewable energy targets beyond:

A wind dominated system would have higher renewable energy penetration rate and requires thermal fleet flexibility. Compared to official renewable power energy targets, a scenario with more wind (100 GW Wind, 60 GW Solar) would help to achieve a higher annual renewable energy penetration rate (26% compared to 22%) due to higher capacity factors of wind, reduce Co_2 emissions by additional 6.1% and entail lower renewable energy curtailment. Owing to its relatively less variable net load profile, the higher wind scenario would create fewer conditions requiring thermal power plant flexibility.

A 250 GW renewable energy system could achieve India's nationally determined contribution target, but 16% annual renewable energy curtailment in the southern region would likely signal the need for modified strategies. To identify more valuable path way towards 250 GW, additional studies can under-taken to evaluate the trade-off between increasing system flexibility and locating more renewable energy capacity in other regions.

Potential planning and policy actions would support renewable energy integration. Coordination of renewable energy generation and transmission at state level would ensure sufficient in state transmission.

Creation of regularity and policy guidelines to support institutionalisation of cost optimised capacity expansion planning. Creation and maintenance of a nationwide model that helps optimise generation and transmission builds-outs, which can then be used to make informed investment decisions and renewable energy policies.

Evaluating options for enhanced coordination of scheduling dispatch amongst states and regions. Establishing comprehensive regulations at the central and state levels regarding the flexibility of conventional generators, including the minimum generation level, ramp rate and minimum up time and downtime.

Revising policy regularity level guide lines to utilise the full capability of hydro & pumped hydro stations. Suitable incentive mechanisms can encourage the operation of hydro and pumped hydro depending on system requirements.
Creating model purchase agreements for renewable energy that moves away from must run status and employ alternative approaches to limit financial risks, such as annual caps on curtailed hours.
Detailed, model based planning, including capacity expansion and including capacity based expansion and production cost modelling would help in achieving more ambitious renewable energy levels. Regularity guidelines may be issued to make it mandatory for stakeholder to provide to provide data required to perform such studies.
Equipping all states with latest state of the art load forecasting facilities. In addition equipping renewable energy rich states with state of art renewable energy forecasting tools. Further building capacity of all system operators in order to develop their in house capability to create and customize such tools in the future.
The Renewables Interactive Map is a research tool for tracking the development of renewable energy worldwide. It complements the perspectives and findings of the GSR by providing constantly updated market and policy information and detailed exportable country profiles.

9. FUTURE SURVEY OF RE

Renewable energy in India comes under the purview of the Ministry of New and Renewable Energy (MNRE). Newer renewable electricity sources are targeted to grow massively by 2022, 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. Such ambitious targets would place India amongst the world leaders in renewable energy use and place India at the centre of its International Solar Alliance project promoting the growth and development of solar power internationally to over 120 countries.

India was the first country in the world to set up a ministry of non-conventional energy resources, in the early 1980s. India's overall installed capacity has reached 329.4 GW, with renewables accounting for 57.472 GW as of 14 June 2017. 61% of the renewable power came from wind, while solar contributed nearly 19%. Large hydro installed capacity was 44.41 GW as of 28 February 2017 and is administered separately by the Ministry of Power and not included in MNRE targets.

From 2015 onwards the MNRE began laying down actionable plans for the renewable energy sector under its ambit to make a quantum jump, building on strong foundations already established in the country. MNRE renewable electricity targets have been

up scaled to grow from just under 43 GW in April 2016 to 175 GW by the year 2022, including 100 GW from solar power, 60 GW from wind power, 10 GW from bio power and 5 GW from small hydro power. The Ministry of Power has announced that no new coal-based capacity addition is required for the 10 years to 2027 beyond the 50 GW under different stages of construction and likely to come online between 2017 and 2022[l]The ambitious targets would see India quickly becoming one of the leading green energy producers in the world and surpassing numerous developed countries. The government intends to achieve 40% cumulative electric power capacity from non-fossil fuel sources by 2030.

Conclusion

This paper examines whether the current renewable energy resources in India are potent enough for meeting the energy sufficiency aspirations of India. The paper identifies the estimated potential of each of the major renewable resource in Indian context and creates two different scenarios for renewable growth in India – Theoretical Maximum Renewable Energy (TMRE) and Realistic Maximum Renewable Energy (RMRE). A simple logistic model has been used for forecasting the penetration of the different renewable technologies in each of the scenarios. The results from the model show that solar power will probably reach its saturation level by 2034–2036. Thoughthis seems too optimistic, the Indian governments accelerated push towards reaching a solar deployment of 100,000 MW by 2022 might catalyse an extended spurt of rapid solar capacity development, leading to the realization of the above steep target. The other renewable energy technologies have, sort of, taken a backseat ever since the government has taken a solar-intensive renewable development agenda. This reflects in the results from the simple logistic model, and it is expected that wind power might achieve its saturation level by 2042–2045; small hydro power by 2059–2062; and biomass power and bagasse cogeneration by 2037–2043. However a caveat needs to be dropped here that all these projections are based on the current estimates of the estimated potential, and projections based on the trends so far. Many a times, the estimated potential sees an upward revision with advanced technology coming into play. Also, dedicated focussed national missions by the government can be game changers for a particular technology, as is already being witnessed in the case of solar power in India.It has further determined that consumers buying green power have the option of obtaining Clean Development Mechanism (CDM) benefits and Renewable Energy Certificates (RECs), whenever these are introduced.so our present responsibilities to use in proper way of Renewable Energy Coordinating and intensifying research and development activities in new and renewable sources of energy; Ensuring implementing of Government's policies in regard to all matters concerning new and renewable sources of energy. The analysis shows that though the current renewable resources can provide a sizeable chunk of the future electricity demand in India, they can't be considered the be-all and end-all of Indian energy policy. There remains a lot of thinking to be done by India's energy future planners on what can be other viable options for meeting the energy sufficiency aspiration of the country.

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