

Renewable energy for sustainable development in India: Current status, Potential and future prospects

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Introduction : Energy is the driving force of the planet earth. Energy, when calculated per unit time is referred to as power. Renewable energy, as the name suggests is the kind of energy that can be renewed such as solar, wind, biomass, tidal, etc. Sun is the ultimate source of almost all forms of power available on the earth directly or indirectly. It releases energy, when two hydrogen atoms fuse to form helium atom, the process commonly known as fusion, which means joining of two things. It is responsible for the solar power direct utilisation, climate and weather changes on earth leading to wind, photosynthesis process for plant growth, etc. Solar power consists of about 50% visible rays and 40% infrared rays and harmful ultraviolet rays, which is obstructed by the ozone layer. Solar power is estimated as 1368 W/m², but nearly 1000 W/m² of power reaches us, the remaining being lost away due to scattering in the atmosphere and other phenomenon. Today, solar power is used widely throughout the world in the form of photo-voltaic modules for electricity generation, solar water heaters for generation of steam which can run produce electricity through turbines, etc. The regions with good solar insolation round the year must opt for solar modules, specially for free of cost electricity generation. Wind energy is also used for electricity generation through windmills. Windmills are suitable for such places where there is pressure difference and winds are generated such as coastal areas, mountains, hills, etc. Biomass is another renewable form of energy, which can be used as fuels by methane gas generation through anaerobic digestion, biomass briquettes combustion, etc. For any country of the world, the renewable methods are the best and sustainable mainly in terms of cleanliness and causes almost no pollution, unlike using the limited fossil fuels such as coal, oil and natural gas, which is not only responsible for the world's one-third green house gas emissions, but also costly many a times.

Electricity demand in different sectors shows that out

of total of 762 TW-hr energy demand, the highest energy is consumed by the industries (336 TW-hr), followed by the residences (175 TW-hr) and agriculture (136 TW-hr). It indicates that agriculture consumes a high share of about 18% of the total electricity demand of our country. The power supply status in the country from 2009–2010 to 2017–2018 shows that at the normal loads, the deficit was 10.11% in 2009-10, which decreased to 0.7% in 2017-18. Also, at peak loading times, the deficit was 12.72% in 2009-10, which decreased to 2% in 2017-18. The data indicates that there have been great improvements in case of power supplies in the past 10 years.

Potential : According to the annual report of the Ministry of New and Renewable Energy (MNRE) for 2017–2018, the estimated potential of wind power was 302.251 GW (at 100-m mast height) and for solar is 748.990 GW. India lies in the northern hemisphere of our earth, with Tropic of Cancer passing through India, dividing India into two halves, being the southern tropical region with great solar radiation and the northern sub-tropical region, also with good sun radiation intensity. Therefore, India has great potential for solar energy utilization which can done through Photo-voltaic cells for generating electricity, solar thermal applications, etc. India is aiming for renewable energy generation of about 175 GW by 2022, which has a major share of solar projects and wind projects of 100 GW and 60 GW, respectively and remaining 15 GW from other sources such as biomass energy, etc.

Development : Estimated contribution of renewable energy sources to the total energy demand in 2021-22 is 20.3%, which needs to be improved further to reduce the usage of coal, oil, natural gas, etc. India's cumulative renewable power capacity increased drastically in the four years, *i.e.* 35.5 GW in 2013-14 to 70 GW in 2017-18. The cumulative installed solar capacity increased drastically by more than 8 times in the last 4 years from 2.63 GW (2013–2014) to 22 GW (2017–2018).

The installed capacity of renewable energy in India-

Table 1 : Potential for renewable energy production for different states

Sr. No.	Power type	Name of States
1.	Solar power	Rajasthan followed by Jammu and Kashmir, Maharastra, Madhya Pradesh, Andhra Pradesh, Gujrat and Himachal Pradesh.
2.	Wind power	Gujrat followed by Karnataka, Maharastra, Andhra Pradesh and Tamil Nadu.
3.	Small hydropower	Karnatakafollowed by Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh, Chhattisgarh and Andhra Pradesh.
4.	biomass power	Punjab followed by Maharastra, Uttar Pradesh, Madhya Pradesh and Haryana.
5.	Overall total power potential	Rajasthanfollowed by Gujrat, Maharastra, Jammu and Kashmir, Karnataka, Andhra Pradesh, Madhya Pradesh and Tamil Nadu.

source-wise (MW) shows that from the period of 2007-08 to 31.12.2018, *i.e.* in about 10 years, the solar power installed capacity has increased around 12,000 times, something hard to believe. Also, the wind power during the same period has increased about 4.5 times, for small hydro power projects, the increase was about 2.2 folds, for biogas plants was 7 times and from waste to energy being 1.6 times increased values. Also, the overall increase in the installed capacity of the renewables was about 7 folds in the past 10 year period, which gives a clear indication of India’s cleaner fuel and self-reliance pledge.

Targets and accomplishments : Solar capacity addition compared to the target between 2013–2014 and 2018–2019 showed great results in terms of target completion. During the 2013-16 period, the maximum target was 1400 MW, which was completed satisfactorily. Looking at the good target completion results, the target was increased, say for the year 2017-18, the target was raised to 10,000 MW, *i.e.* about 10 times and still 9363 MW power plants were installed, which shows the good target completion. Wind power capacity addition compared to the target between 2013-14 and 2018-19 shows that the target has been increased from 2500 MW in 2013-14 to 4000 MW in 2018-19, which was also attained satisfactorily, except for the year 2017-18, in which only 1766.25 MW was installed against a target of 4000 MW. The wind power installation target is lesser as compared to the solar power, which may be due to the complex installation process of the windmills. Biomass power target, achievements and cumulatives shows that the target has been reduced from 405 MW in 2013-14 to 250 MW in 2018-19. The target was achieved satisfactorily for all the years, except for the year 2016-17.

Cumulative energy generation from renewable energy source-wise, 2014–2019 shows that the biomass, bagasse, waste to energy and the small hydropower energy production has declined in the past 5 years, whereas solar

and wind power share increased.

Annual growth : The annual growth in power generation as per 30th of November 2018 shows very high growth rate in the 3 financial years’ *i.e.* 2016-17, 2017-18 and 2018-19, where the growth of renewable electricity generation was around 25% for each of the 3 years as compared to the 7% growth only, for the financial year 2015-16. The data reflects the activeness of the government for the past 3 financial years’. Cumulative installed renewable energy capacity shares shows that Percentage of renewable energy shares in the total installed capacity was 3% in 2002 and in 2022 being 32%.

Ranking of the states : Cumulative electricity generation from renewable energy-state-wise shows that from the session 2015-16 to 2018-19, for almost all the states, the electricity generation increased but not more than 2 folds, whereas for the 2 states such as Andhra Pradesh and Telangana, the rise was 3.5 and 4 times, respectively.

The estimated renewable potential in India reveals the facts of India’s potential at different geographical locations for different renewable power source types, given below rank wise in the following Table 1.

Conclusion : The most contributing renewable power types for Indian conditions are solar power and wind power and a few states having both in abundance such as Maharastra, Gujrat and Andhra Pradesh. But, still Rajasthan state has the highest total energy potential due to the solar energy available in abundance. Off-grid solar applications included many products, the highest number of sold products being the solar lamps, followed by the solar homes, street lights and solar water pumps The use of the renewable energy based products would not only provide us with free energy, but also pollution free sustainable energy which would act as a boon for our mother earth.

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