

Alternative Energy: The Global Scenario

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Introduction

The current challenge faced by the world in recent times is to cater to the energy needs for human well-being, economic development and alleviation of poverty. However, since our current energy system is still dominated by fossil fuels (coal, gas and oil), carbon dioxide and other harmful greenhouse gases emitted by these sources are a major contributor to global warming. The world is spending a lot of time to come out of this trade-off and possibly, the answer lies in switching to sustainable energy sources.

Renewable energy may be defined as the energy from various self-replenishing sources that is limited in flow. This energy is derived from the sources that cannot be depleted. Various forms of renewable energy that are being produced and consumed globally are solar, wind, geothermal, hydropower and biomass.

In the Paris Climate Change Agreement 2015, participating nations agreed to keep the global average temperature rise below 2 degrees Celsius. This calls for huge reduction in energy-related carbon dioxide emissions, achievable only with the introduction of renewable forms of energy such as wind, solar and hydropower. Policies on renewable energy

are instrumental in its wide expansion. These policies help to mitigate institutional, economic and technical barriers faced by various nations. Around 168 countries are setting renewable energy goals. Policy mechanisms like feed-in tariff (FIT), green certificate or auctions system have been increased by 61 countries from 2010 to 2017.

Energy demand globally rose by 2.3 per cent from 2010 to 2018 both in terms of fossil fuels and alternate fuels, leading to a 1.7 per cent increase (i.e 33.1 Gigatonnes) in energy-related carbon dioxide emission [International Energy Agency, 2019]. But, major economies, such as the United States, the United Kingdom, Mexico and Japan witnessed decline in carbon emissions owing to better renewables deployment. Demand for oil, natural gas and coal increased by 1.3 per cent, 4.6 per cent and 0.7 per cent respectively in 2018 from 2010. The renewable sources have witnessed highest growth rate primarily, driven by wind, solar and hydropower. The global electricity demand has grown by 4 per cent from 2010 to 2018, to more than 23,000 TeraWatt-hour (TWh) [International Energy Agency, 2018].

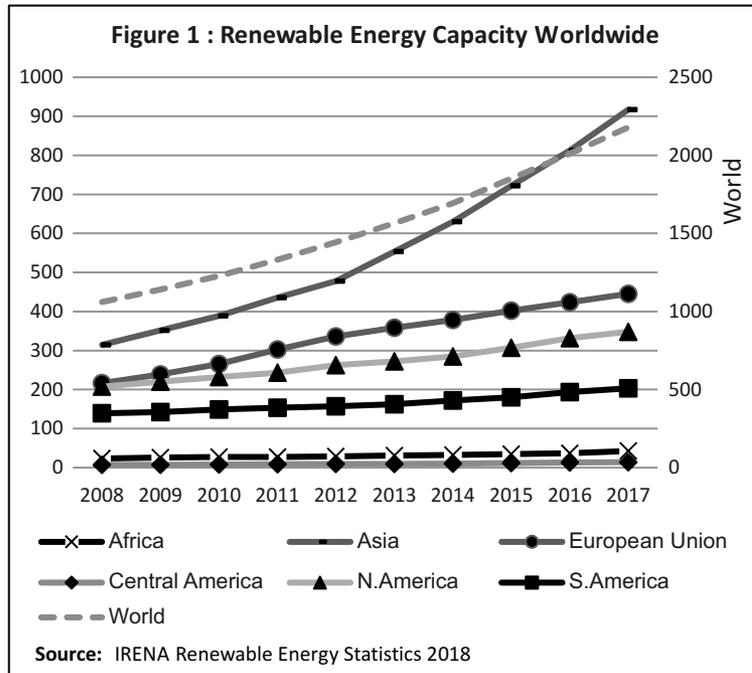
The International Renewable Energy Agency (IRENA) has urged nations to contribute 36

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per cent of world's total energy consumption through renewable energy by 2030 as put forth by a report titled 'Remap 2030'. The investment cost on renewable energy expansion will be offset by the associated costs of fossil fuel pollution leading to a saving of US\$740 billion per year. As per IRENA, renewable power generation capacity is measured as the maximum net generating capacity of power plants and other installations that use renewable energy sources to produce electricity.

26.5 per cent of the global electricity production in 2017 has been obtained from renewable resources. The major contributors to this share are hydro power (16.4 per cent), followed by wind power (5.6 per cent), bio power (2.2 per cent), solar PV (1.9 per cent) and marine and geothermal energy (0.4 per cent) globally¹. This article primarily focusses on the major players of various renewable resources across the world.

The steep increase in the total renewable energy capacity worldwide from 2008 to 2017 is depicted in Figure 1. While Asia shows maximum renewable energy capacity usage of 917.322 Gigawatts (GW), Central America

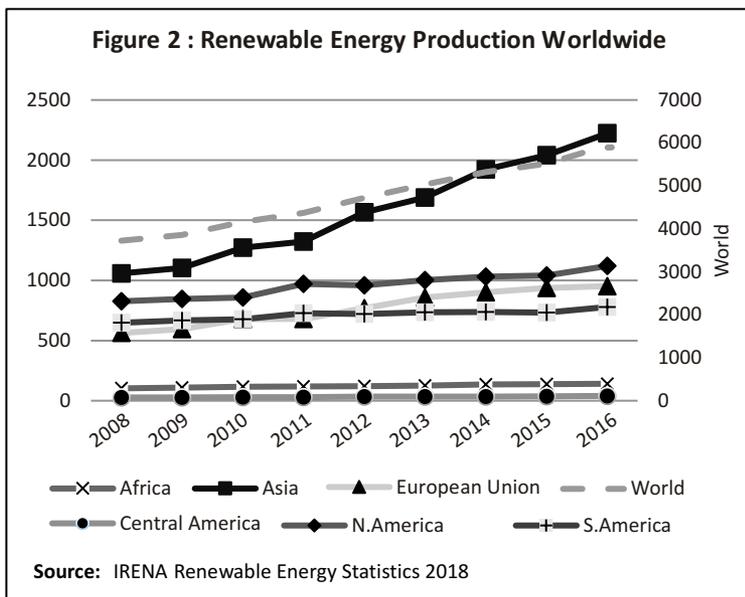


demonstrated the minimum capacity usage at 14.08 GW in 2017. Thus, Asia alone contributes to about 42 per cent of the world's total capacity of renewable energy, followed by European Union contributing to 20.4 per cent of the same in 2017.

Figure 2 shows an increase of about 58 per cent in the total renewable energy production globally from 2008 to 2016. Asia contributed around 38 per cent of global total renewable energy production in 2016.

At this backdrop, this article discusses the global scenario with respect to the use and potential of renewable/alternative energy sources, the economic and social benefits of implementing various alternative energy

¹Renewables 2018 Global Status Report



energy. The increasing concerns of environmental pollution, depletion of ozone layer owing to greenhouse gases are forcing economies worldwide to invest in the alternative energy sources. The continuous depletion in traditional energy resources along with frequent changes in the crude oil prices are now acting as the major drivers for use of renewables worldwide. Countries have still not

sources worldwide, the progress of developing countries in shifting to alternative energy with special reference to India vis-a-vis the developed nations of the world.

It is observed that the renewables comprises of one-third of the electricity generation in Europe, one-fourth in China and one-sixth in the United States, India and Japan². The developing economies accounted for 63 per cent of the total renewable energy investment with China alone accounting for 45 per cent of global investment in 2017³.

The Global Scenario

It is observed worldwide that there is a strong relation between economic growth and implementation of various forms of renewable

achieved economies of scale for renewables as applicable for fossil fuels. Both developed and developing countries are investing in renewable energy implementation for a successful switch from traditional sources to alternative sources.

The maximum average global investment in renewables in developing and developed countries was observed in 2015 [FS-UNEP Centre Report and BNEF Global Trends Report, 2018]. There was a decline in the investment in the following years for developed countries. However, it increased for the developing countries in 2017 (Figure 3).

The world's renewable energy capacity showed a sharp increase of 171 GW from 2017 to 2018 out of which around 61 per cent

²Enerdata Global Energy Statistical Yearbook 2018

³Renewables 2018 Global Status Report

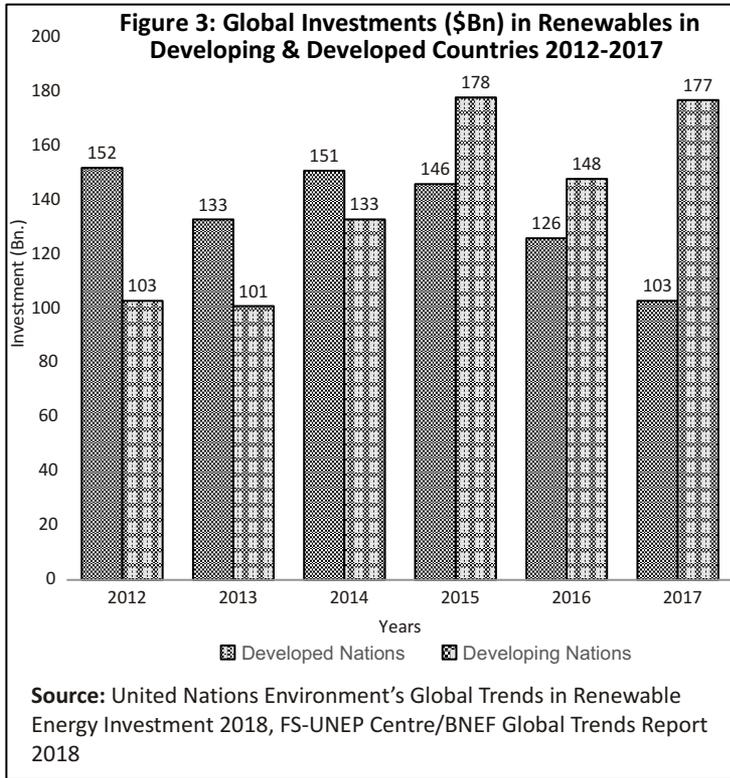


Figure 4 shows that among the various forms of electricity, hydropower is the leading renewable source for electricity generation globally, supplying 41.2 per cent of all renewable electricity.

Forms of Renewable Energy and their Usage

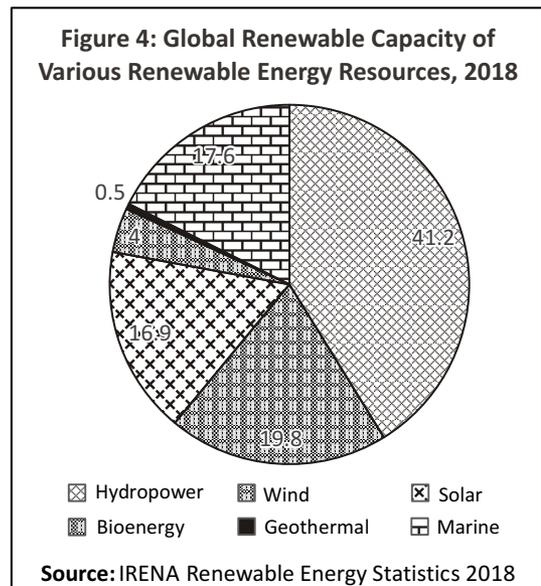
Solar Energy

Solar radiation is emitted by the sun. Photovoltaic collectors and thermal collectors are two predominant solar energy technologies. Various advantages of solar energy usage are continuous

was installed in Asia itself. Asia accounted for a cumulative capacity of 1024 GW in 2018.

The Global Wind Energy Council (GWEC) predicts that around 55 GW global wind power capacity will be added per year till 2023. The Council also declares the commissioning of 51.3 GW new wind capacity in 2018, out of which 46.8 GW is onshore and remaining 4.5 GW is offshore.

It is observed that the global renewable capacity is 2844 GW in 2018, owing to a steep increase in hydropower, wind, solar, bioenergy, geothermal and marine. In the total renewable energy capacity for the world as depicted in

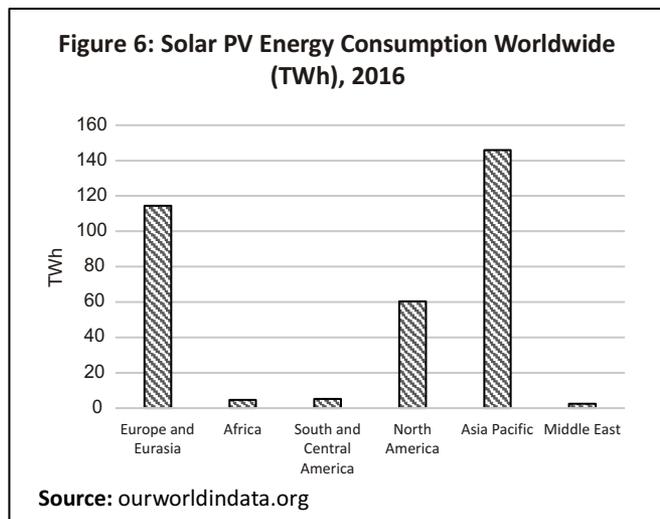
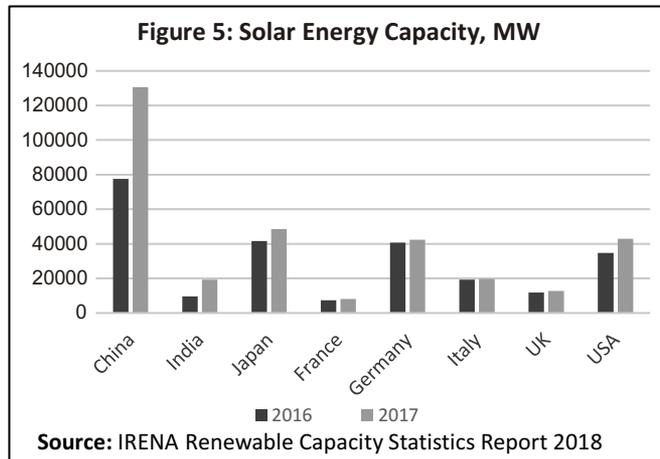


availability, production of both heat and electricity, lower maintenance cost of solar energy systems along with the reduction in electricity bills. There are certain disadvantages too, such as, high initial installation cost of solar energy systems, reduction in the efficiency of solar energy systems on cloudy days, excessive space requirement of solar photovoltaic panels and high cost of storage of solar energy.

China (130,646 MW) has emerged as a world leader in solar energy capacity surpassing Germany (42,396 MW) in 2017. USA, Japan and Germany were still much ahead of India during the years 2016 and 2017 and the total capacity of India was 19,275 MW in 2017 (Figure 5).

Figure 6 depicts that the biggest consumer of solar PV energy is the Asia Pacific with 146 TWh consumption followed by Europe and Eurasia with 114.4 TWh in 2016. The lowest consumption of solar PV energy is observed in the Middle East i.e. 2.46 TWh.

In India, one of the major achievement in the solar energy sector has been the sanction of 41 solar parks in 21 states with an aggregate capacity of over 26,144 MW. The installation of largest solar park of 2,000 MW at Pavagada is in progress. Few off grid solar initiatives are taken in the last four years such as doubling of



solar street lights, distribution of 25,75,000 solar lamps to students, around 1.5 per cent increase in solar home lighting systems and setting up of several solar pumps [MNRE, 2018].

Wind Energy

Wind energy has seen phenomenal growth in its usage worldwide in recent times because

clean and non-polluting technology is used in this case to generate electricity. It is unlimited and freely available in nature. However, the wind turbines may cause noise pollution causing damage to local wildlife like birds.

In 2017, China emerged as the global world leader in wind energy capacity followed by USA and Germany (Figure 7). From 2016 to 2017, China showed an increase of 10.12 per cent and India showed as an increase of 14.56 per cent. As per the World Economic Forum, China's fast technology upgradation, large land mass and long coastline are the main reasons for the tremendous progress in wind energy capacity and generation.

Around 80 per cent of the total wind capacity is produced by China, USA and Germany and remaining 20 per cent is produced by countries worldwide [REVE, 2016]. Therefore, it is clear that more initiatives should be undertaken by the developing

countries of the world for a better tomorrow.

In India, the Ministry of New and Renewable Energy (MNRE) has provided certain incentives to promote wind energy generation and usage such as generation-based incentives of 0.50/kWh, import duty concession on specified wind turbine parts, reliefs on excise duty and finally, income tax waiver to wind power projects.

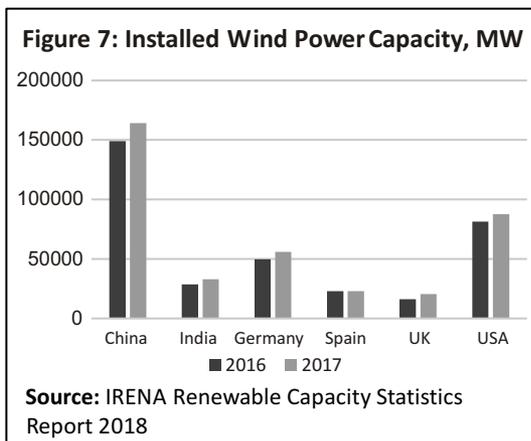
Hydroelectric Power

Hydropower is the conversion of energy from flowing water into electricity. It is a renewable form of energy which is derived from flowing water. Various advantages of hydropower are renewability and ease of availability. Fueled by water, it is a clean source of energy. It is flexible source of electricity as the water flow can be monitored with respect to the electricity output required.

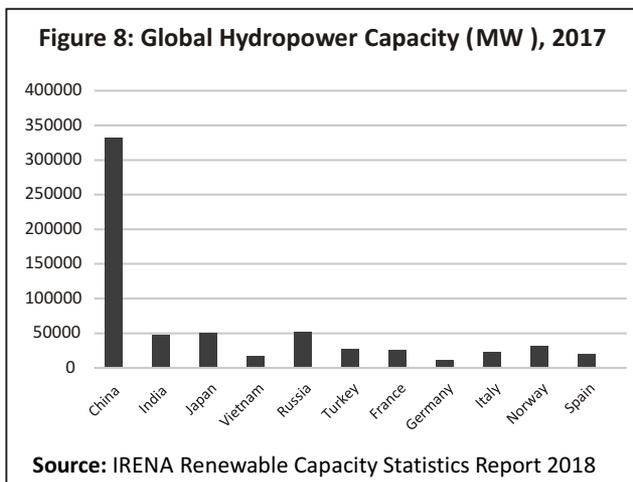
The IRENA Renewable Capacity Statistics Report 2018 shows China as the leader in total hydropower capacity in 2017 followed by Russia and Japan (Figure 8).

Three Gorges Dam in China is the world's largest hydropower plant with a capacity of 22.5 GW. It produces 80 to 100 TWh of electricity per year which can cater to the needs of 70-80 million households⁴.

Owing to its vast mountain ranges and many rivers, hydropower potential of China is the largest in the world. China is the world's largest producer of hydroelectric power. It is



⁴<https://www.irena.org/hydropower>



now aggressively building dams. About 16 per cent of China's electricity is generated by hydropower in 2016. China's future plans is to increase its hydro-generating capacity by nearly two-thirds over the next five years⁵.

In India, small hydro projects of 682 MW have been added over the last four years till 2017. 600 watermills for mechanical applications have also been added. Around 132 projects are still under consideration [MNRE,2018].

Geothermal Energy

The thermal energy which is generated and stored in the Earth is called the geothermal energy. The major players in this energy sector are Iceland, El Salvador, New Zealand, Kenya, and Philippines. Geothermal energy caters to meet more than 90 per cent of the heating demand in Iceland in 2018 [IRENA, 2018]. Since, geothermal energy production does not

depend on weather conditions and has very high capacity factors, geothermal power plants are capable of supplying electricity as well as providing ancillary services. The disadvantages includes pollution and improper drilling of earth may lead to release of hazardous minerals and gas in the atmosphere.

USA, Philippines, Indonesia, Turkey and New Zealand are the leading countries availing commercial exploitation with worldwide

installation of around 12,800 MW at the end of 2017 [REN21, 2018]. Total geothermal energy rose worldwide from 11,209 MW in 2014 to 13,329 MW in 2018 [IRENA,2018].

In 2013, the Geological Survey of India has identified about 340 geothermal hot springs in the country. Out of these, many are in the low surface temperature range from 37°C-90°C which is appropriate for direct heat applications. There are seven geothermal provinces in the country viz. Himalayan (Puga, Chhumathang), Sahara Valley, Cambay Basin, Son-Narmada-Tapi (SONATA) lineament belt, West Coast, Godavari basin and Mahanadi basin.

Bioenergy

Bioenergy is a form of renewable energy extracted from living organic materials known as biomass that can be used to produce fuels for transportation, heat and electricity

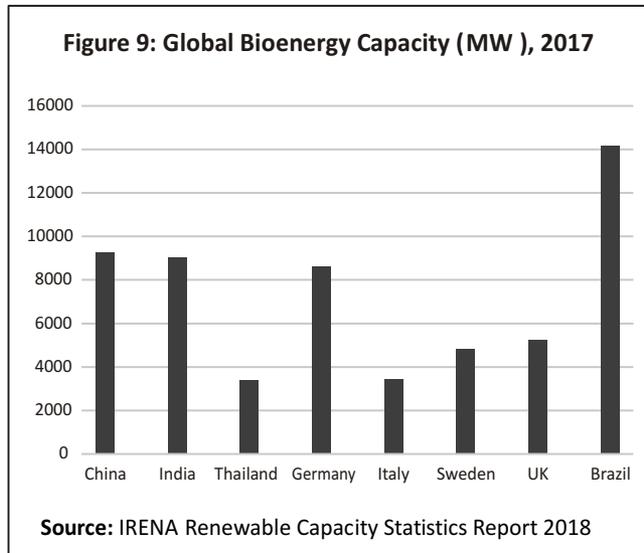
⁵<https://www.worldenergy.org/data/resources/country/china/hydropower/>

generation. Two major conflicts that arise due to biomass production are shortage of land (either food production or bio-fuel production) and humungous greenhouse gas emissions from land management and land use change. Bioenergy is generated from bio-mass that is widely available and also a cleaner source of energy.

Europe has the major biofuel production capacity accounting to about two-third of the total global capacity [Welfle, 2017]. Brazil is a global leader in bioenergy with its capacity of 14,583 MW in 2017 followed by China and India (Figure 9).

The Indian states leading in establishing biomass based power supply are Maharashtra, Uttar Pradesh and Karnataka, 2.5 lakhs biogas plants have been set up in India in the last four years till 2017 for helping rural livelihoods. India being an agriculture based country, it is very difficult to find lands for bio-mass production as most of them are already used for production of edible crops. At the same time, India being the 7th largest country in the world spanning 328 million hectares is amply bestowed with renewable energy resources including biomass.

India produces about 450-500 million tonnes of biomass per year. Biomass provides 32 per cent of all the primary energy needs in the country at present. There is about 63 million hectares (ha) waste land in the country, out of



which about 40 million ha can be developed by undertaking plantations of *Jatropha* [MNRE, 2018].

International Experience: Select Cases

The Nordic countries like Sweden, Denmark, Iceland, Norway, Finland are major players in low carbon energy transitions. Sweden is implementing renewable technologies among all its sectors leading to a sharp increase in its economic growth and humungous reductions in wastes and greenhouse gases. It has set its target to be a completely fossil fuel-free nation by 2040. It is on its way to achieve its renewable energy targets by 2019 which was projected to be achieved by 2030 due to the installation of 3681 new wind turbines in 2018. It basically depends on wind energy utilization followed by biofuels. Sweden relies on hydropower for electricity generation and on biofuels for heating purpose. [Urban et al.,

2018]. Iceland relies almost fully on geothermal energy for heating purposes and on hydropower alongwith geothermal energy for electricity generation. Finland depends predominantly on hydropower and biofuels. A major share of Norway's electricity comes from hydropower alone.[Urban et al.,2018].

Alaska is a a well-known player in solar, wind, hydroelectric and geothermal energy. The rural areas are more inclined towards renewable energy alternatives owing to high oil prices. Around 20.2 per cent of installed electric capacity comes from renewable energy facilities of the state. There is a huge usage of biomass fuels such as wood, sawmill waste, fish byproducts and municipal waste in Alaska to generate renewable energy. Alaska has initiated tax incentives on renewable and hybrid energy.

Costa Rica ran almost 250 days totally on renewable energy. Data from World Bank highlighted 100 per cent electricity generation from hydropower by Albania and Paraguay in 2013. Artificial intelligence is extensively used for renewable energy production in Europe. European Union, is on the verge of decarbonization of its energy system by 2050.

India's Position and Performance on the Global Platform

The population of India is expected to surpass that of China by 2022. This growth in population signifies substantial rise in India's

share of global primary energy demand. Improvements in energy efficiency will assist in cutting the growth in energy demand. Renewable energy sources offer a sustainable route to address the energy security concerns. The year end review 2018 of the Ministry of New and Renewable Energy (MNRE) put forth that India has been ranked fifth globally for overall installed renewable energy capacity, fourth for wind power installed capacity and fifth for solar power installed capacity.

India's renewable energy consumption is expected to move up fifteen folds⁶ by 2040. The potential of renewable energy in the country is huge and largely unexploited. India ranked fourth on the EY Renewable Energy Country Attractiveness Index 2018 preceded by Germany in the third position, United States in the second and China occupying the topmost position. India is thus among the top five attractive renewable energy markets in the world. Again, the nation is ranked eleventh globally in the Climate Change Performance Index 2019 due to an improved performance in renewable energy, comparatively low levels of per capita emissions and an ambitious mitigation target for 2030.

While India made 9.1 GW Solar PV additions in 2017 leading to a total Solar PV capacity of 18.3 GW at the end of the year 2017 [REN21, 2018], China added an astounding 53.1 GW in the same year leading to a total Solar PV capacity of 131.1 GW at

⁶<https://www.bp.com/en/global/corporate/energy-economics/energy-outlook/country-and-regional-insights/india-insights.html>

the end of 2017. From the point of view of Concentrating Solar Thermal Power, while India's total capacity at the end of 2017 has been 225 MW, China's capacity has been just 20 MW. In terms of wind power, India occupied 6 per cent of the total global wind power capacity as on end-2017; China occupied around 35 per cent whereas Brazil occupied 2.4 per cent of the total capacity of the world.

India ranked fourteenth in 2017 globally in the production of biofuels with 1 billion litres production. India's first biomethane-fuelled bus commenced operation in 2017. Among the BRICS, the countries that are in top ten in this respect are, Brazil being second on the global platform with 32.8 billion litres production and China being fifth with 4.3 billion litres production.

While from the point of view of hydropower additions India is third in the world in 2017 with an addition of 1.9 GW in the year, in terms of the total hydropower capacity the country occupied the sixth rank with a share of 4 per cent of the total capacity of the world. China, Brazil and Russian Federation occupied the first, second and fifth ranks respectively from the point of view of total capacity (with a share of 28 per cent, 9 per cent and 4.3 per cent of the total global capacity respectively).

The share of renewables in electricity generation for India in 2017 has been 16 per cent, whereas this share for China is 26 per

cent and for Brazil it is as high as around 80 per cent [Enerdata, 2018]. However, the share of wind and solar in electricity generation has been 5.1 per cent for India in 2017. It has been around 6.8 per cent for China and 7.4 per cent for Brazil.

In 2017 for the eighth year in a row, global new investment in renewable energy (excluding hydropower projects larger than 50MW) exceeded US\$ 240 billion. Total new investment globally has risen from US\$ 158.9 billion in 2007 to US\$ 279.8 billion in 2017 [REN21, 2018]. Majority of the investment in 2017 took place in solar PV and wind power. Government R&D and corporate R&D taken together has seen a rise of about 68 per cent in 2017 as compared to 2007. However, venture capital and private equity (VC/PE) investment in renewable energy fell by 68 per cent from US\$ 5.6 billion to just US\$ 1.8 billion during the same period. But, asset finance of renewable energy projects totalled US\$ 216.1 billion in 2017, an increase of 88 per cent on US\$ 115.1 billion in 2007. Small-scale distributed capacity however rose to US\$ 49.4 billion in 2017 which is 3.5 times of the figure in 2007. China, India and Brazil accounted for just over half of global investment in renewables excluding large hydro in 2017, with China alone representing 45 per cent.

In 2017, India attracted an investment of US\$ 10.9 billion in the renewable energy sector with the major share of investment in solar

energy (61 per cent of the total investment) followed by wind (37 per cent)⁷. For China the invested amount in renewable energy in 2017 has been as high as US\$ 126.6 billion with 68 per cent of the investment in solar and 29 per cent being in wind. Brazil's total new investments in 2017 has been US\$ 6 billion with the majority of the share of investment in wind sector (60 per cent) followed by solar energy (35 per cent).

In India, the FDI equity inflow in the non-conventional energy sector has shown an increasing trend during the period 2015-16 till 2017-18 [MNRE, 2018]. During the period from April 2018 till June 2018, the FDI inflow has been US\$ 452.89 million making the total inflow since April 2015 till June 2018 amount to US\$ 3,217 million.

Potential and Progress in Renewable Energy in India

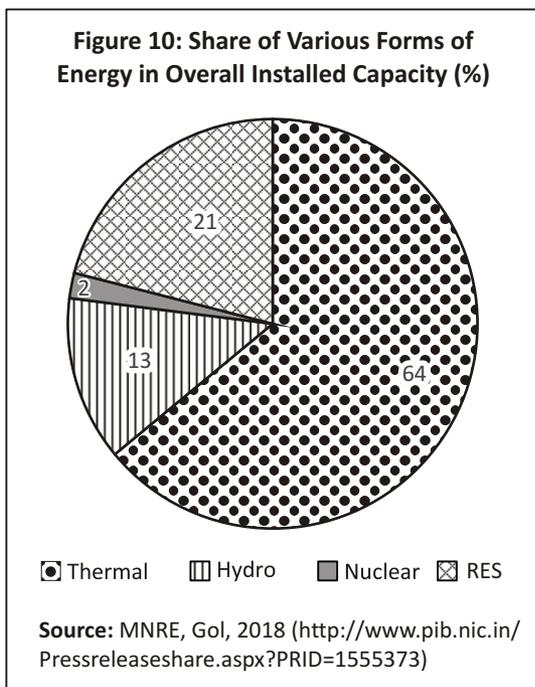
The potential for renewable power generation in India as on March 31, 2017 has been estimated at 1001 GW which includes solar power potential of 649 GW, wind power potential of 302 GW (at 100 m level), biomass power potential of around 19 GW, potential of 7 GW from bagasse-based cogeneration, waste to energy potential of 2.6 GW and small hydro power potential of 21 GW [MOSPI, 2018]. However, it should be noted here that hydro power projects up to 25 MW were categorized as renewable energy in India in

2017. The top three states in India in terms of estimated potential of wind power at 100 m level are Gujarat with 27.9 per cent of the total wind power potential for India followed by Karnataka (18.5 per cent) and Maharashtra (15 per cent). Again, the estimated potential of small hydro power (SHP) is highest for Karnataka with a share of 17.6 per cent of the total SHP potential for India, followed by Himachal Pradesh (16.4 per cent) and Arunachal Pradesh (9.8 per cent).

The estimated potential of biomass power has been the highest for Punjab with 17 per cent of the total estimated potential for India. The state is followed by Maharashtra (10.6 per cent of the total) and Uttar Pradesh (9.5 per cent). Again, the estimated potential of solar power is highest in the country for Rajasthan with a share of 21.9 per cent of the total potential for India, followed by Jammu and Kashmir (17.1 per cent) and Madhya Pradesh (9.5 per cent).

74.79 GW of renewable energy capacity has been installed in India as on December 31, 2018 from sources viz. wind, solar, SHP and bio-power against a target of 175 GW of renewable energy capacity to be installed by 2022 [MNRE, 2019]. The share of renewable energy in overall installed power capacity in India as on October 31, 2018 has been 21 per cent as shown in Figure 10. Renewable energy sources here include small hydro project, bio power, solar and wind energy.

⁷ Frankfurt School-UNEP Centre/BNEF. 2018. Global Trends in Renewable Energy Investment 2018, <http://www.fs-unep-centre.org> (Frankfurt am Main)



of the total installed capacity of grid interactive wind power in India) stood first among the Indian states followed by Gujarat (16.95 per cent) and Maharashtra (13.63 per cent). In terms of solar power, Karnataka (with 20.84 per cent of the total installed capacity of grid interactive solar power in India) occupied the first rank followed by Telangana (13.53 per cent) and Rajasthan (12.42 per cent). With respect to bio-power, the top three states include Maharashtra (with 25.49 per cent of the total installed capacity of grid interactive bio-power in India) followed by Uttar Pradesh (21.35 per cent) and Karnataka (18.15 per cent). In terms of SHP, Karnataka (27.24 per cent of the total installed capacity in India) again occupied the first rank followed by Himachal Pradesh (19.05 per cent) and Maharashtra (8.31 per cent). When the total installed capacity of grid interactive renewable power comprising of all four forms of power are taken in to account, Karnataka held the first rank among the Indian states, followed by Tamil Nadu and Maharashtra.

The top three states in India as on December 31, 2018 in terms of the installed capacity of various renewable modes of energy are depicted in Table 1. From the point of view of wind power, Tamil Nadu (with 24.56 per cent

Table 1: Top 3 States in India in terms of Installed Capacity of Grid Interactive Renewable Power as on 31.12.18

Wind Power		Solar Power		Bio Power		SHP		All 4 Renewable Energy Sources	
States	% of total	States	% of total	States	% of total	States	% of total	States	% of total
Tamil Nadu	24.56	Karnataka	20.84	Maharashtra	25.49	Karnataka	27.24	Karnataka	17.34
Gujarat	16.95	Telangana	13.53	Uttar Pradesh	21.35	Himachal Pradesh	19.05	Tamil Nadu	16.03
Maharashtra	13.63	Rajasthan	12.42	Karnataka	18.15	Maharashtra	8.31	Maharashtra	12.44

Source: MNRE, Gol, 2019 press release (<http://www.pib.nic.in/Pressreleaseshare.aspx?PRID=1564039>)

As per the Paris Accord on Climate Change, India has pledged that by 2030, 40 per cent of installed power generation capacity shall be based on clean sources.

From the perspective of off-grid power, decentralized renewable power ventures using wind energy, bio-power, hydro power and hybrid systems are being set up to meet the energy needs of remote regions which are not expected to be electrified in the near future. The MNRE also supports deployment of various decentralized solar applications in the country. The off-grid solutions help in accessing modern energy services in an environmentally sustainable and timely manner.

Conventional energy resources in India being quite low in comparison to its energy needs in terms of the huge population and rapidly increasing economy, the nation can harness the vast potential of renewable energy resources to meet the needs.

Conclusion

One-third of global power capacity is based on renewable energy at present [IRENA, 2019]. There is more focus in recent times on renewable energy due to energy security concerns and environmental issues. Impressive growth in renewable energy worldwide is witnessed with 171 GW of renewable energy additions made to the global system in 2018. Asia has been the largest installer of renewable energy with 61 per cent of total capacity additions. China and India

are progressing more than several developed countries to curb their use of fossil fuels and increase the share of renewables. In 2017, China banned usage of coal in its 28 cities providing a great boost to the renewable energy sector. In addition to this, establishment of several renewable energy heating related targets were done in the country's 13th Five Year Plan. China has emerged to be the global leader in renewable energy. The largest market for the solar thermal-driven chillers along with solar thermal cooling installations was Asia owing to China, India and Singapore. With prices of renewable energy sources plummeting, rise in investment in the sector along with renewable energy targets set for many countries in the continent, this sector is set to experience rapid expansion in near future. Asian governments are now committed to promote the sector with favourable regulatory frameworks, financing platforms, better infrastructure, land allocation for renewable energy projects and industry-oriented research and development.

References

- Enerdata (2018). Global Energy Statistical Yearbook 2018.
- International Energy Agency (2019). The Global Energy and CO2 Status Report.
- International Energy Agency (2018). The Global Energy and CO2 Status Report.
- IRENA (2019). Renewable Energy Accounts for Third of Global Power Capacity.
- IRENA (2018). Renewable Capacity Statistics Report.
- MOSPI (2018). Energy Statistics 2018.

Ministry of New and Renewable Energy (MNRE) (2018). 4 year Achievement Booklet.

MNRE (2018, 2019). Press Releases. Press Information Bureau, MNRE, GoI.

REN21 (2018). Renewables 2018 Global Status Report.

Urban, F., and Nordenvard, J. (2018). Low Carbon Energy Transitions in the Nordic Countries: Evidence from the Environmental Kuznets Curve. *Energies*, 11, 2209.

Welfle, A. (2017). Balancing Growing Global Bioenergy Resource Demands - Brazil's Biomass Potential and the Availability of Resource for Trade, Biomass and Bioenergy, 105, 83-95.

REVE (2016). Wind Energy and Electric Vehicle Review.