India's Future Energy: A Shift to Renewables

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***Abstract*: The present situation of pollution in India and world is really alarming and it is becoming worse day-by-day. One of the major causes of pollution is the use of fossil fuels for production of energy. It is the right time for us to shift our energy resources to renewable looking at the results of environment pollution in the metropolitan cities of the country. Also, the availability of fossil fuels in near future is going to be a question mark. Hence, we must take a step forward shifting our resources to renewables to meet our energy needs in order to compensate the availability of fossil fuels in near future. Also, it will help us to reduce present level of pollution and people will be able to live in pollution free environment.**

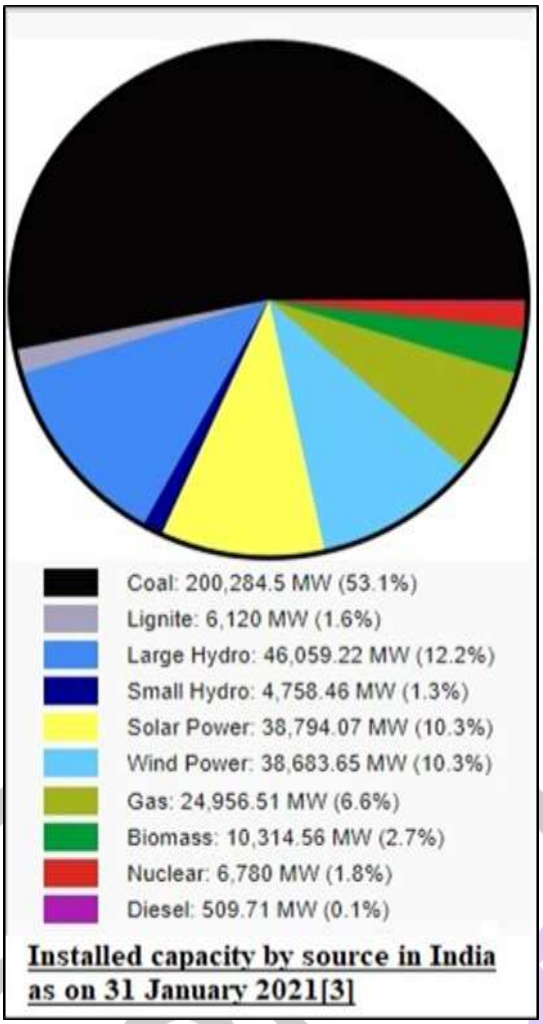
Index Terms: Shift to renewables, Scarcity of fossil fuels, Pollution free energy generation, Quit fossil fuels, Solar, Wind, Hydro.

1. Why quit fossil fuels?

Fossil fuels (coal, oil, gas) have, and continue to, play a dominant role in global as well as Indian energy systems but we can't ignore that the energy generated from the fossil fuels comes at the cost of harming our Environment.
Environment Scientists have been continuously showing concerns about the rising temperature of the earth due to global warming. Environment Scientists have also been warning about the rise in the environmental temperature between 1.8-degree F (1 degree C) and 3.6 degrees F (2 degrees C), as after the rise of 2 degrees C the climate change will be irreversible and is not possible to bring it back to normal conditions. The pace at which the earth's temperature is rising, would not take more than 10 years for the climate changes to become irreversible.
Also, the availability of fossil fuels is decreasing day-by-day. If we continue to exploit it at the same pace in which we are using it now, its availability will be uncertain after few years.
Hence, it is the right time for us to shift its energy sources to renewables as they are eco-friendly and their access is unlimited.

2. Why India should shift its energy to Renewables?

India is the third largest consumer of fossil fuels [1]. The use of fossils to such a large extent is causing an increase in environmental pollution and environmental temperature at an alarming rate. Being an agricultural country, we can't afford a remarkable increase in environmental temperature as it would have adverse effects on rainfall and other seasons which in turn will harm our agricultural yields.
Also, the population in India is increasing at an alarming rate and as a result to that the usage of electricity is also increasing as the present scenario the non-renewable resources such as coal, woods and other fuels are used to compensate the usage but this is resulting in depletion of these non-renewable resources. With power demand expected to triple by 2040 as India's population continues to achieve upward mobility, fossil fuels are poised to see continued growth even as the clean energy market thrives. But the days are very near when these fossil fuels will be extinct from earth and will no longer be available as a source for electricity generation. Hence, we must find alternate sources such as solar, wind, hydro, biomass, etc. to tackle the real-time situation.
Also, we must not forget that agriculture is the primary source of livelihood for about 58 % of India's population [2]. The share of agriculture in GDP is about 19.9 %. Being an agricultural country, we will be worst affected by the climate change. Hence, we must take a step forward towards the solution to this climate change.
As the second-largest coal-producing [13] and -consuming [14] country on earth and the third-largest [15] emitter of greenhouse gases, India's transition from carbon-intensive resources is a critical front in the global climate change fight. Challenges lie ahead, but there may be cause for optimism. As the country grapples with the intertwined issues of air pollution, water scarcity and energy security, along with energy access and affordability, experts say that they're starting to see a future for India where coal will no longer be king.
We can clearly see that coal is used widely in India for the electricity generation. The use of renewable energy such as solar, wind, hydropower and many others have very low around 10% (each) contribution. Hence, we must increase our dependence on renewable sources for the production of electricity to meet our demand that is increasing rapidly.
Also, we import a lot of coal for the electricity generation, switching to renewables will also help us to save a large part of capital. According to estimates by the World Economic Forum, by shifting towards renewables, India can save over $90 billion in imports between 2021 and 2030; this, even if half the generated renewable power is used to replace imported coal.
India has one of the best solar, wind and hydro potentials in the world, these resources are well distributed all over its area and with prices of solar cells declining so fast every year, there is no reason why India cannot achieve its climate change targets and also achieve a fully sustainable energy system until the middle of this century. India has seen an exponential growth in its renewable energy sector in the past few years. Though our installed renewable energy capacity is already the fifth [16] largest in the world, there is much more potential in this sector. Driven by a highly conducive policy environment, a steady influx of capital and new technologies, days are near when India will be leader of consuming renewable energy to meet its energy demands.



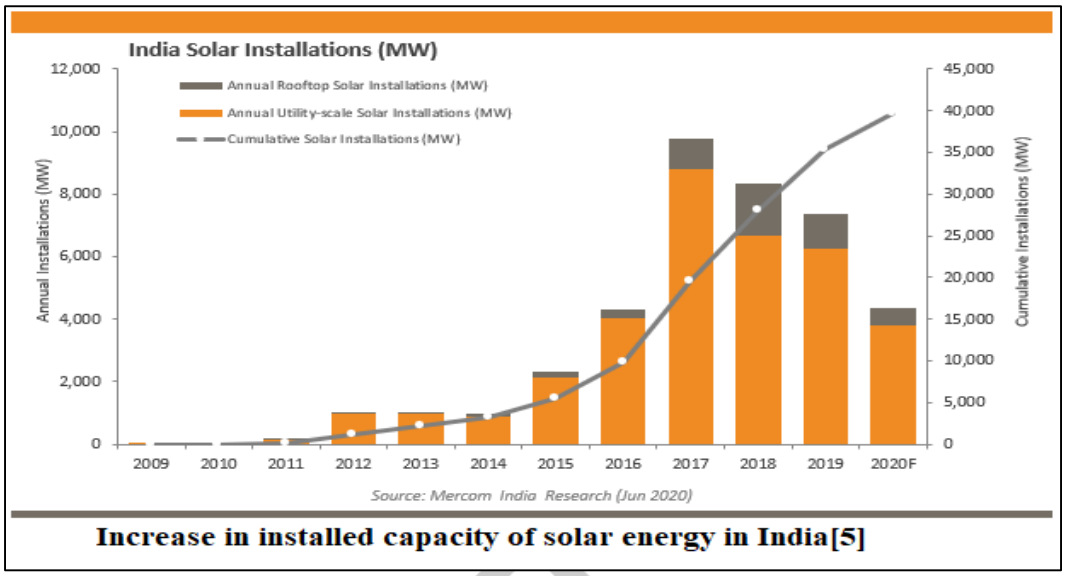
Installed capacity by source in India as on 31 January 2021[3]

Hence this is the right time for us to shift to renewables to meet our energy demand. So that we are ready for that tough time when these fossil fuels will be in scarcity.

3. Solar Power

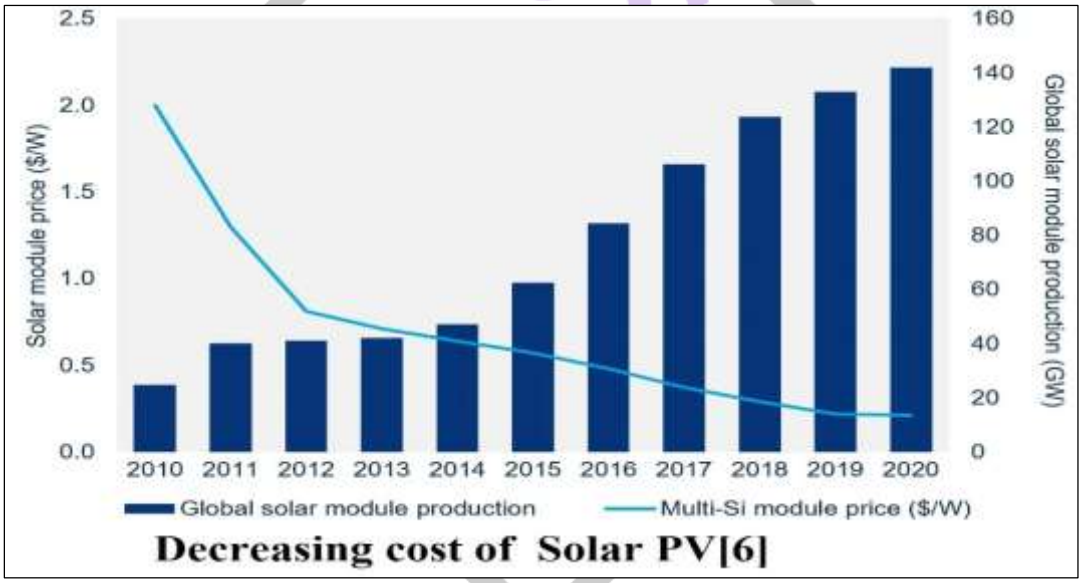
Sun is the ultimate source of energy and solar energy has a key role to play in energy sector of our country. It can be a game changer in shifting our energy sources to renewables. Being a tropical country solar is a boon for us and it can be harness to meet most of our energy demand. With about 300 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 [4]. The solar energy available in a single year exceeds the possible energy output of all of the fossil fuel energy reserves in India. With this much of potential available we can definitely put a full stop to the use of fossil fuels.

Solar energy is a very flexible energy technology it can be built as a distributed energy system where each and every household, offices will have their own small solar plants generating the energy for their personal use, off the grid. We can also have large on-Grid solar power plants similar to traditional solar power plants that will be generating energy and providing to grid as done by other traditional power plants. The off grid solar panels installed in the farms, rooftops, etc. can also be connected to the local grid so that they can also play a vital role in providing the excess energy generated by their solar panels to the grid for further distribution. They can also be encouraged to store energy in batteries for the use when their solar panels are mot generating energy especially for night times. This will help us to make homes and offices self-reliable in energy and can help us to achieve our aim of shifting completely to renewables. Solar exists within a complex and interrelated electricity system. Working alongside other renewable technologies like wind power, hydro power, tidal, biomass, etc. to transition the India to a clean energy economy.



Increase in installed capacity of solar energy in India[5]

We can see that the installed capacity of solar energy is increasing every year and we have reached to a mark of about 40,000MW (approx.) till June 2020. Electricity generated from solar in Quarter 3 2020 crossed 13 billion units [22]. But there is still a long way to go as this contributes only a small percentage of India's energy need. The government has undertaken various initiatives and programs for increasing the contribution of solar energy in meeting our country's energy need, but the citizens too have to come forward and give their vital contributions in this noble cause of transforming India to clean energy economy.

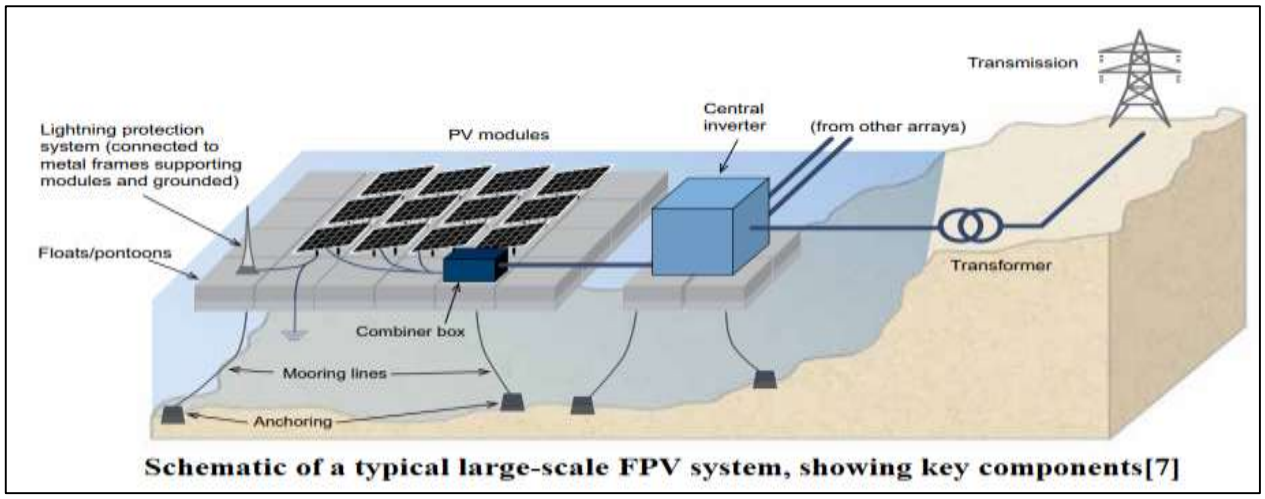


Decreasing cost of Solar PV[6]

We can see that the cost of Solar PV has been continuously decreasing over the years and its efficiency has been improving day-by-day. Hence it can act as the best alternative to the non-renewable sources such as coal. With the new technologies coming up in solar, in coming years we will be seeing that the solar will be having low LCOE than that of other fossil fuels. Then it is going to be much cheaper to generate electricity from solar instead of fossil fuels. More and more module manufacturers are offering warranties that last up to 30 years, which put solar power plants' lifetime on par with that of natural gas and coal power plants. The additional electricity generation near the end of a solar project's lifetime would also further lower the LCOE and increase competitiveness in the marketplace. The new decade will see the global solar energy industry tapping into innovative technologies to enhance long-term project performance while continuing to lower system costs.

3.1 Floating Solar Power Plants

We can see that the solar has a lot of potential when it comes to generation of electricity but for the densely populated countries like India it becomes very difficult to have large in-land solar power plants. The major solution to this problem can be floating solar power plants. India is known as land of rivers; we have large of water bodies and are surrounded by sea from 3 sides. Hence it is very efficient and easier for us to install more and more floating solar power plants. This will also help to save water from evaporating and save our water resources.



Schematic of a typical large-scale FPV system, showing key components[7]

FSPV also known as floatovoltaics is a solar PV application in which PV panels are designed and installed to float on waterbodies such as reservoirs, hydroelectric dams, industrial ponds, water treatment ponds, mining ponds, lakes, and lagoons. In this, solar panels are usually mounted upon a pontoon-based floating structure and to keep its location fixed, floating structure is anchored and moored.

The major benefit of floating solar power plant is that it can have as much as 10% improved efficiency than that of the in land solar power plants [8]. Correlations between the solar PV array yield, solar PV array temperature, and local weather conditions such as ambient temperature, wind speed, solar irradiance, etc. are well known. These correlations indicate that reduction in ambient temperature and higher wind speed reduces the solar PV array temperature which in turn results in higher energy yield. As the ambient temperature at the vicinity of a waterbody is generally lower than the ambient temperature at land and wind speed tends to be higher over open water surfaces as to on land, it resulting in an evaporative cooling effect. This effect results in lower operating temperatures of the PV cell, which in turn improves the energy yield [8].

According to a new study by The Energy and Resources Institute (TERI), India's reservoirs have 18,000 sq. km of area with the potential to generate 280 GW [9] of solar power through floating solar photovoltaics (FSPVs) plants. The number is really fascinating and can have a large share in India's energy mix.

We can see that the Floating photovoltaics are becoming quite popular in other countries due to increased efficiency and other advantages such as less water evaporation, easy installation and deployment over inland solar power plants. With such a large number of water reserves India can definitely take a lot advantage of this latest technology in solar sector.

4. Hydro Power

Hydropower (from the Greek word hydro, meaning water) is energy that comes from the force of moving water. The fall and movement of water is part of a continuous natural cycle called the water cycle.

Hydropower is called a renewable energy source because the water on Earth is continuously replenished by precipitation. As long as the water cycle continues, we won't run out of this energy source.

Regardless of the exact mechanism behind each individual hydropower source, the basic principle of hydropower is that we can use moving water to spin turbines and generate electricity. The driving force behind most hydropower applications is the water cycle. Water evaporating from rivers, lakes, and oceans condenses in the atmosphere and returns to the surface of the earth as precipitation, which flows through streams and rivers. This moving water contains energy that can be harnessed to generate hydroelectricity by spinning turbines. A typical hydroelectric plant brings in flowing water through a pipe (known as a penstock) that funnels the water to turbines. This flowing water forces the turbines to spin a generator and produce usable electricity.

India has an estimated hydropower potential of 1,45,320 MW [10], out of this as of 31 March 2020, India's installed utility-scale hydroelectric capacity was 46,000 MW [11]. Although India is already the fifth (5^{th})-largest [12] hydropower capacity in the world. There is a lot of potential left behind which we can harness and get benefitted, and can be at further top positions in the table.

4.1 Major Types of Hydropower Plants

There are 4 broad hydropower plants: (1) storage hydropower, (2) pumped-storage hydropower, (3) run-of-river hydropower, (4) offshore hydropower [17].

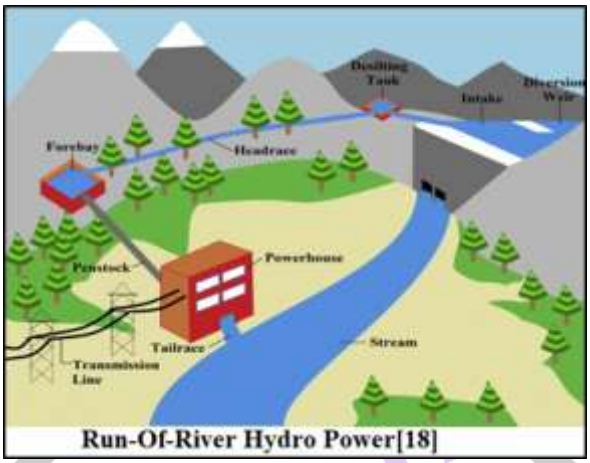
Perhaps the most well-known and recognizable type of hydropower is **storage hydropower**. A storage hydropower plant involves damming a river and creating a reservoir that stores large amounts of water. Water is released from the reservoir behind dams and flows through turbines, spinning them and producing electricity. Storage hydropower plants provide a fairly consistent baseload of electricity production, meaning they can supply relatively constant power and also have the capability to meet peak electricity demand by allowing more water through the turbine systems in a short period of time. Conversely, a storage hydropower plant can be completely shut down in times of low electricity demand.

Pumped-storage hydropower (PSH) is the most developed energy storage technology in the world today. Similar to storage hydropower systems, pumped storage hydropower relies on water flowing through turbines from a reservoir at high elevation to a lower elevation release point. The difference between storage and pumped storage is that pumped storage systems include pumps

that transport water back up to the higher elevation reservoir. At times of peak electricity demand, the pumped water is released back through the turbines to meet high consumer demand.

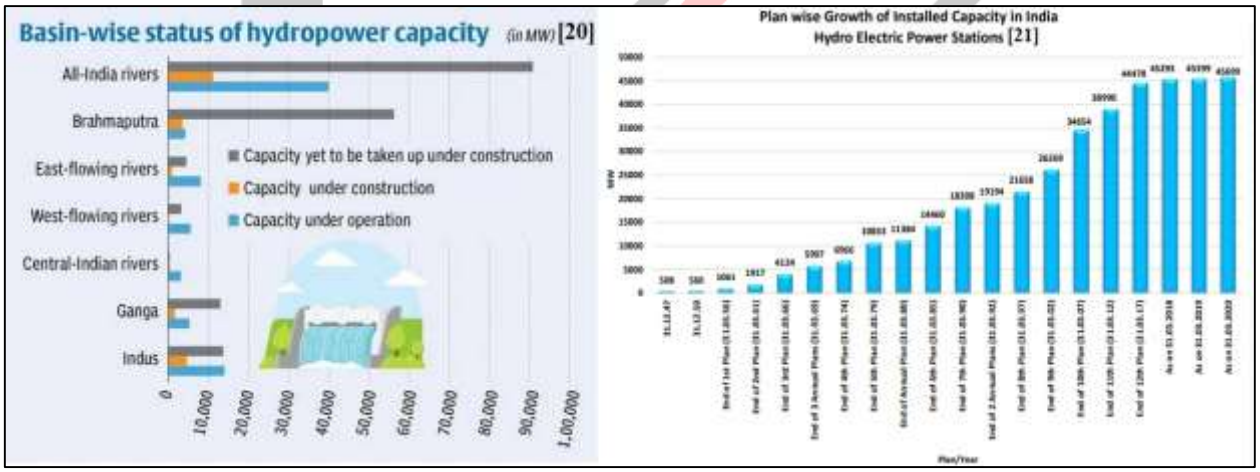
Run-of-river hydro projects use the natural downward flow of rivers and micro turbine generators to capture the kinetic energy carried by water. Typically, water is taken from the river at a high point and diverted to a channel, pipeline, or pressurized pipeline (or penstock). The technology is applied best where there is a considerably fast-moving river with steady seasonal water. How much electrical energy can be generated by a hydroelectric turbine depends on the flow/quantity of water, and the height from which it has fallen (the head). The higher the head, and the larger the flow, the more electricity can be generated.

Run-Of-River projects are seen as a "green" alternative to high-dam hydropower projects such as the Tehri Hydropower Project. This is because an ROR dam diverts the river flow in a controlled environment to generate electricity and sends the water back to the river, whereas a high-dam project stores river water in a reservoir.



Run-Of-River Hydro Power[18]

With the three major all season rivers Ganga, Indus & Brahmaputra and many other such rivers emerging from Himalayas, India has a very large potential of setting up large scales Run-of-River hydro power Plants. Also, these power plants will be completely eco-friendly as we do not need to store any water, we can utilize the potential flow of these rivers for the generation of electricity. Traditional hydro dams are expensive and time consuming to build. Comparatively speaking, run-of-the-river systems are less expensive to build and can be built over a shorter period of time. Run of river systems also avoid some of the environmental problems associated with the flooding, since the pondage is much smaller than the lakes for traditional hydro. Thus, for the country like India which are having a number of all-season rivers, Run-of-river hydro-power can be a boon in its objective of switching to renewables. Also The efficiency of today's hydroelectric plant is about 90 percent [19]. Hydroelectric plants do not create air pollution, the fuel--falling water--is not consumed, projects have long lives relative to other forms of energy generation, and hydroelectric generators respond quickly to changing system conditions.



We can clearly observe that capacity of rivers yet to be taken up for construction of hydropower is larger than that already taken for construction. Whereas we can also notice that the increase in the installed capacity of hydropower in India is not that much encouraging. The number has been almost constant for last few years. We need to increase our hydropower capacity as it can serve as the major source of electricity when we quit fossil fuels. Also, hydropower can be the most promising source of energy during night time and the times when sun is not available and solar does not work.

5. Wind energy

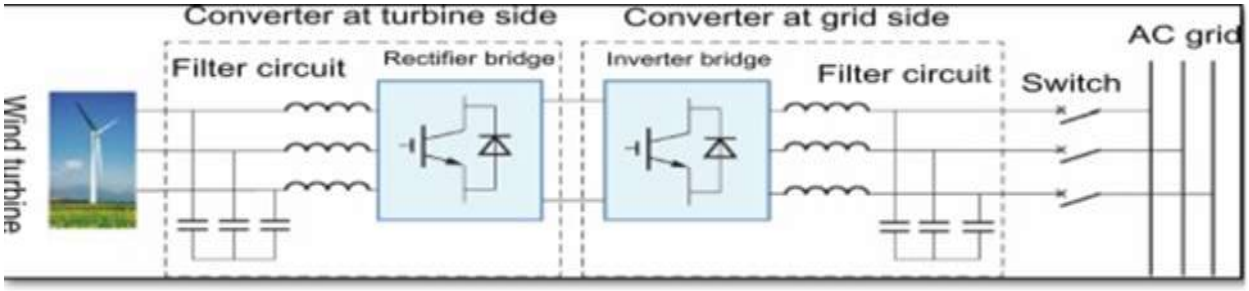
The rising concerns over global warming, environmental pollution and energy security have increased interest in developing renewable and environmentally friendly energy sources such as wind, solar, hydropower, geothermal, hydrogen and biomass as the

replacements for fossil fuels. Wind energy can provide suitable solutions to the global climate change and energy crisis. The utilization of wind power essentially eliminates emissions of CO2, SO2, NOx and other harmful wastes as in traditional coal-fuel power plants or radio-active wastes in nuclear power-plants. By further diversifying the energy supply, wind energy dramatically reduces the dependence on fossil fuels that are subject to price and supply instability, thus strengthening global energy security.

5.1 Wind Power Generation

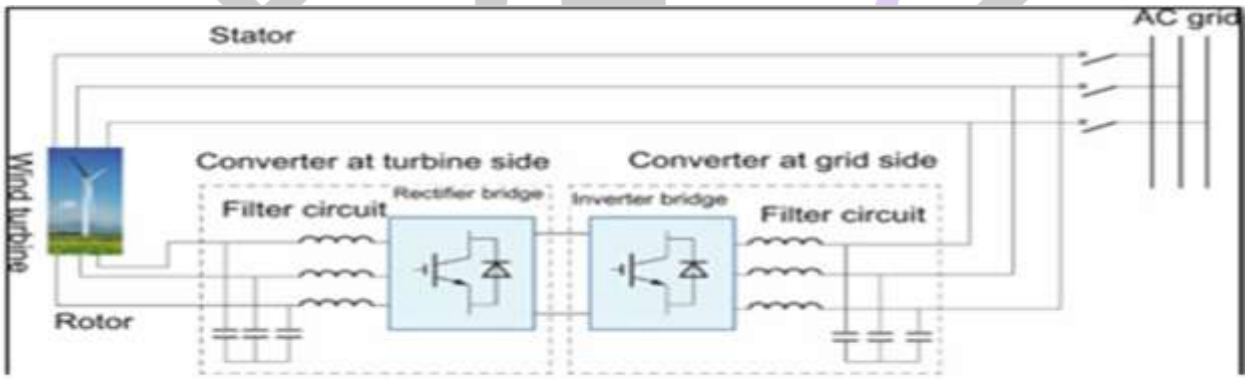
Wind Power Generation is power generation that converts wind energy into electrical energy. The wind generating set absorbs wind energy with a specially designed blade and converts wind energy into mechanical energy, which further drives the generator rotating and realizes conversion of wind energy into electrical energy.

The commonly used wind power generation systems include the direct-driven wind power generating set, the direct-driven wind power generating set is connected to the grid through a full power converter, while the double-fed wind power generating set is connected to the grid through a double-fed converter.



Direct-driven permanent magnet synchronous wind power generation system. [23]

Fig. [23] shows a direct-driven permanent magnet synchronous wind power generation system. For this system, wind energy drives the wind turbine rotating, which further drives the generator running, converting mechanical energy into electrical energy. The stator of the permanent magnet synchronous generator outputs AC power with variable amplitude and frequency. By passing through an AC/DC rectifier, the AC power will be inverted into DC power and then, with a DC/AC inverter, the output DC power will be inverted to AC power and connected to the AC grids. The power flows unidirectionally from the wind turbine to the AC grid. When it is only required to be connected to DC grids, the DC/AC inversion step can be omitted.



Double-fed wind power generation system. [23]

Above Fig. shows the double-fed wind power generation system. Both the stator and the rotor of the double-fed generator can supply power to the grid, in which the rotator is connected to the grid through a converter, while the stator is connected to the grid directly. In case of speed change of the generator rotator, the converter will ensure the stator rotating magnetic field and the grid are in the same frequency by regulating the frequency of exciting current.

5.2 India's Unique Proposition:

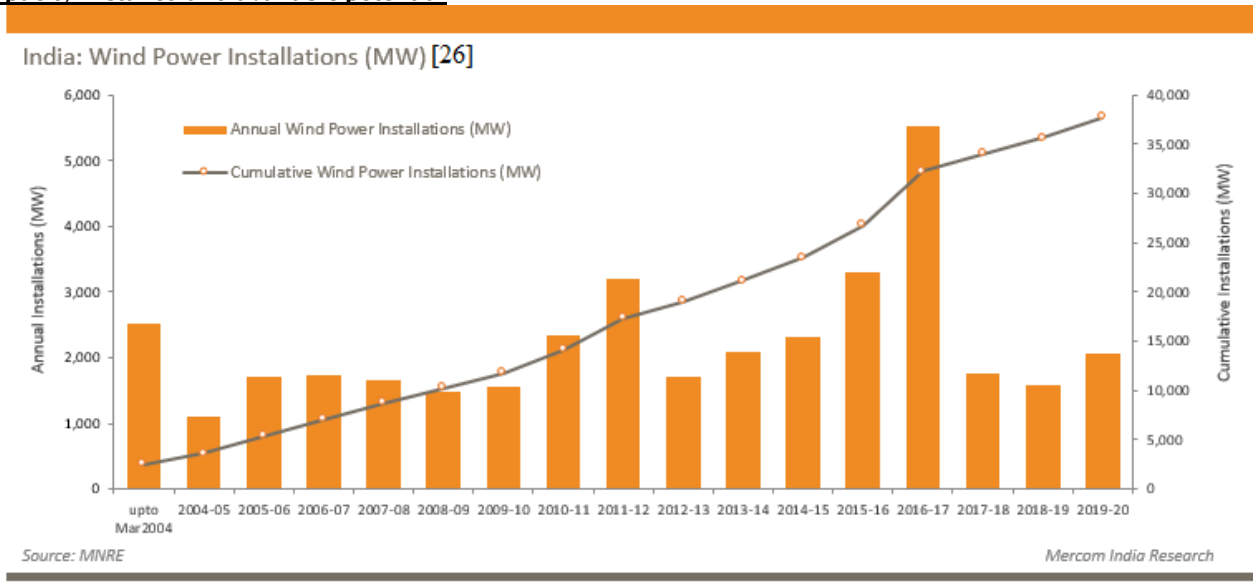
The potential is far from exhausted. It is estimated that with the current level of technology, the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 65,000 MW [24]. India also is blessed with 7517 km of coastline and its territorial waters extend up to 12 nautical miles into the sea. The unexploited resource availability has the potential to sustain the growth of wind energy sector in India in the years to come.

5.3 Offshore Wind:

India is blessed with a coastline of about 7600 km surrounded by water on three sides and has good prospects of harnessing offshore wind energy. As per the "National Offshore Wind Energy Policy" policy, Ministry of New and Renewable Energy will act as the nodal ministry for development of Offshore Wind Energy in India. Ministry set a target of 5.0 GW of offshore wind installation by 2022 and 30 GW by 2030 [25] which has been issued to give confidence to the project developers in India market.

Offshore wind power offers a plausible alternative in such a scenario. Absence of any obstruction in the sea offers much better quality of wind and its conversion to electrical energy. Offshore wind turbines are much larger in size (in range of 5 to 10 MW per turbine) as against 2-3 MW of an onshore wind turbine. While, the cost per MW for offshore turbines are higher because of stronger structures and foundations needed in marine environment, the desirable tariffs can be achieved on account of higher efficiencies of these turbines after development of the eco system.

5.4 Capacity Installed and available potential



Wind power installations in India rose to 2.07 GW in the financial year 2019-2020, a 31% increase as compared to 1.58 GW in the FY 2018-19. The cumulative installations stood at 37.69 GW as compared to 35.63 GW for the FY 2018-19. According to NIWE, the installable wind potential of the country is estimated to be at 695 GW at 120 meters above ground level. Out of the estimated figure, nearly 347 GW of wind projects can be installed on cultivable lands, followed by wastelands where 340 GW capacity could be possible.

We can clearly find out that out of total 695 GW of potential, we were only able to harness approx. 40GW till 2020. Hence there is a lot more we can get from wind energy. Its potential clearly states that how vital it is going to be shifting the energy need to completely renewable energy.

6. Other renewable sources

6.1Geothermal Energy

Geothermal energy is the heat that comes from the sub-surface of the earth. It is contained in the rocks and fluids beneath the earth's crust and can be found as far down to the earth's hot molten rock, magma. Among the most recent systems for the exploitation of geothermal energy, the most promising are the third-generation ones, also called EGS (Enhanced Geothermal Systems). Their technology allows to dramatically improve energetic efficiency of both geothermal wells and dry rocks. With EGS systems, high-pressure water is pumped underground, with the purpose of increasing or triggering the natural process of geothermal energy.

Finally, another way to increase the exploitation of this type of renewable source is cogeneration, as geothermal fields are often located in proximity of oil and gas fields

6.2 Tidal Energy

In the world of renewable energy, tidal power is one of the more abstract, obscured points of discussion. It's not nearly as mechanically developed as hydro-power or biomass. And it certainly doesn't demand the same sort of press as solar power or wind power. Official estimates of potential in tidal energy stand at 12,455 megawatts (MW) [27] in India whereas other forms of energy such as wave energy provides for additional capacity.

Currently, tidal dams or barrages are regarded as determined energy tools that are capable of producing electricity on a profitable scale. The research and development (R&D) in tidal energy is largely in the field of tidal barriers and turbines. The next epoch is likely to witness the tidal energy becoming a fully profitably sustainable energy source, and thus comprehensive research is significant in tidal energy

6.3 Biogas

Biogas is a locally accessible and renewable energy source that can be generated from organic feedstocks under anaerobic conditions The analysis estimates that the biogas potential ranges from 310 to 655 billion m^3/year in the year 2040 depending upon availability of different resources. The estimated biogas potential in the year 2040 is around 36% [28] of India's current (2015) total primary energy supply in the high availability scenario.

6.4 Biofuel

Biofuel, a renewable energy source produced from organic waste and materials, is a widely used and increasingly controversial energy source in transportation. Replacing fossil fuels with biofuels—fuels produced from renewable organic material—has the

potential to reduce some undesirable aspects of fossil fuel production and use, including conventional and greenhouse gas (GHG) pollutant emissions, exhaustible resource depletion, and dependence on unstable foreign suppliers.

6.5 Biomass

Biomass energy is energy generated or produced by living or once-living organisms. ... Biomass is organic, meaning it is made of material that comes from living organisms, such as plants and animals. The most common biomass materials used for energy are plants, wood, and waste.

India has a potential of about 18 GW [29] of energy from Biomass. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs [29]. Going by the current growth rate in biomass power generation, India is likely to surpass the target of 10 GW [30] by the end of the next fiscal year, way ahead of the target year of 2022.

7. Conclusion

As of now India is utilizing mostly conventional sources of energy especially fossil fuels like coal which cause a lot of pollution and whose availability in future is greatly questioned. Also, we can clearly observe that there is a lot of potential of renewable energies like solar, wind, hydro, etc. in our country but we are not able to harness even 40 % - 45 % (approx.) of it. Hence it is right time to increase our installed capacity and harness more and more of the available renewable energy.

The renewable electricity future is a decentralized and distributed one. The fact is renewable energy is decentralized—sunlight falls everywhere and wind blows everywhere. Demand for electricity too is decentralized, and most renewable technologies are modular. This makes renewable electricity most suitable for decentralized generation and consumption.

Government can vision of a decentralized and distributed electricity future with the increased role for small-scale electricity generators who may be households, businesses and mini-grids. These millions of small generators would meet their own energy requirements and feed excess energy into the grid and draw from the grid when needed. The role of grid, therefore, would change from being the main supplier of electricity to one of a platform where surplus electricity between millions of generators and consumers would be traded and transported.

The Future of India's renewable energy is very bright, the only thing is we all need to contribute for this noble cause and work in a right direction to achieve the aim of shifting energy sources to renewables for meeting our energy demand.

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