



Sectorial Contribution Towards Greenhouse Gases Emissions and Role of Renewable Energy in Reduction of Greenhouse Gases emission in India

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Abstract- The large amount of greenhouse gases (GHGs) being released into the atmosphere has proved to be a globally challenging phenomenon that leads to changes in the climate and global warming. This Paper delivers information on the emission of Greenhouse gases (GHGs) in terms of their emission from different sectors like energy, industrial processes, agriculture and waste. This paper also includes the comparison of emission of cumulative greenhouse gases in year 1994, 2000, 2007, 2010, 2014, 2016 and 2019. This paper also includes the top GHG Emitting Countries from 1990-2019. The emission of GHG cause Global warming and the earth's average temperature is continuously rising. In order to avoid negative potential outcomes of global warming, countries have adopted the United Nations Framework Convention on Climate Change. For developing countries i.e not included in Annex-I, the Clean Development Mechanism was implemented for their sustainable development. Climate change is major environmental challenges facing not only India but also throughout the world today. India is facing several problems. Climate change is associated with various adverse impacts on agriculture, water resources, forest and biodiversity, health, coastal management and increase in temperature. Decline in agricultural productivity is the main impact of climate change on India. This paper also includes the generation of renewable energy for sustainable development in India. The generation of renewable energy helps in the reduction of emission of greenhouse gases and contribute in the sustainable development of the country.

Key Words- Energy, Clean Development Mechanism, Greenhouse Gases (GHG), Renewable Energy

Introduction- Climate change and global warming resulting from human activities is one of the most important environmental challenges in the world. Carbon dioxide (CO₂) and other greenhouse gases (GHG) are emitted into the air coming from several sectors of economic activity such as energy, industrial processes, agriculture and waste, and each year these emissions continue to rise. The emission of GHG increases steadily as growth in the population ^[1]. As they accumulate in the atmosphere, Greenhouse gases increase the risk of negative environmental impacts from climate change. To control the emission of GHG the Kyoto Protocol was framed in 1997. Many governments are developing actions to reduce Greenhouse gases emissions through national policies that include the introduction of emissions trading programs, voluntary programs, energy or carbon taxes, and regulations and standards on energy efficiency and emissions ^[1].

Clean Development Mechanism- The Clean Development Mechanism, or CDM, was a late invention in the negotiation of the Kyoto Protocol. The 1997 Kyoto Protocol, a milestone in global efforts to protect the environment and achieve sustainable development, marked the first time that governments accepted legally-binding constraints on their greenhouse gas emissions. The protocol also broke new ground with its innovative "cooperative mechanisms" aimed at cutting the cost of curbing these emissions ^[1]. As it does not matter to the climate where emission reductions are achieved, sound economics argues for achieving them where they are least costly. The Protocol therefore includes three

market-based mechanisms aimed at achieving cost-effective reductions. International Emissions Trading (IET), Joint Implementation (JI), and the CDM.

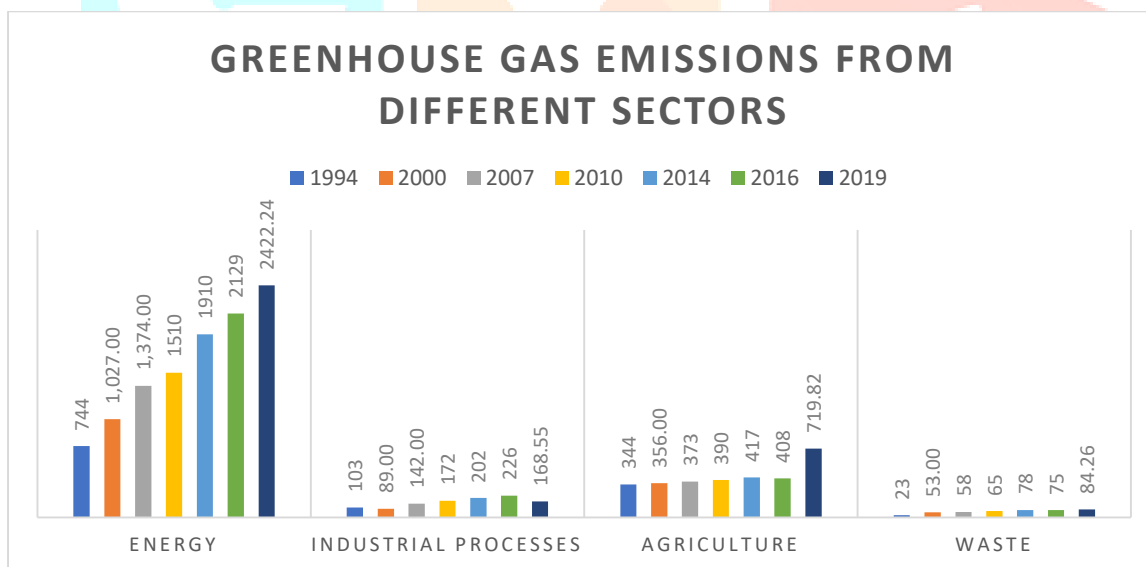
The Clean Development Mechanism (CDM) is a mechanism defined by the Kyoto Protocol, whereby projects with a component that includes the reduction of Green House Gas (GHG) emissions are implemented. The CDM is the only mechanism in the Kyoto Protocol that involves non-Annex 1 countries, by enabling them to host emission reduction project on their territory.

It has two-fold objectives: -

- To assist countries not included in Annex 1 to the UNFCCC (“developing countries”) in achieving sustainable development, and
- To allow countries that are included in Annex 1 to the UNFCCC and have inscribed Specified greenhouse gas (GHG) emission target in Annex B to the Kyoto Protocol (the traditional industrialized countries) to acquire Certified Emission Reduction (CERs) from CDM project activities undertaken in Non-Annex 1 Parties and count them towards their Kyoto targets ^[12].

Potential for CDM in India- The broad potential of Greenhouse gases emission in key sector can understand by reviewing and summarizing existing studies that analyze India’s Greenhouse gases emissions profile and their mitigation options.

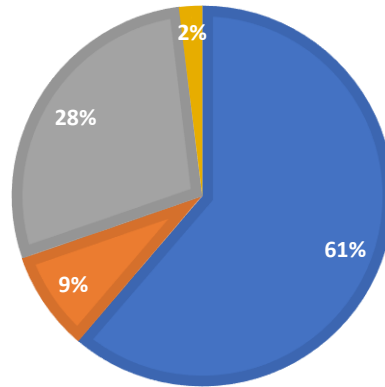
A comparative analysis of GHG emissions from the energy sector (fuel combustion in different sectors) in 1994 with the estimates for 2000 shows an increase from 744 to 1027 MTCO₂ and the increment is continued and reached to 2127 MTCO₂ in 2016. The bulk of this increase is in the energy and transformation sector, and for the most part includes fuel consumed for power generation. The percentage CO₂ emission from energy sector is continuously increasing so it is necessary to find out the renewable energy sources to decrease the emission of CO₂ from energy sector ^[10].



Source: National Communication (2004), National Communication (2012), National Communication (2022) and World Resources Institute

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 1994

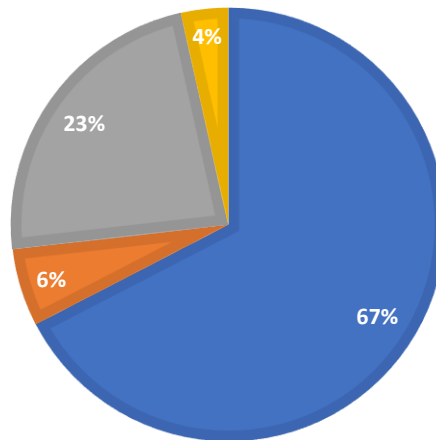
■ Energy ■ Industrial Processes ■ Agriculture ■ Waste



Source: National Communication (2004)

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 2000

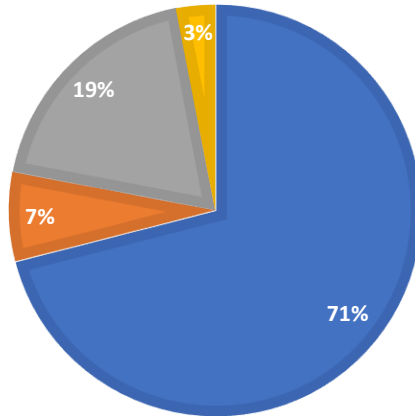
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Source: National Communication (2004)

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 2007

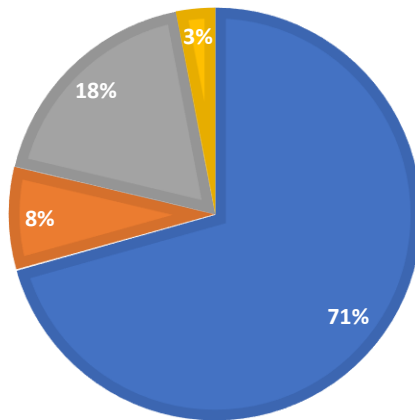
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Source: National Communication (2012)

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 2010

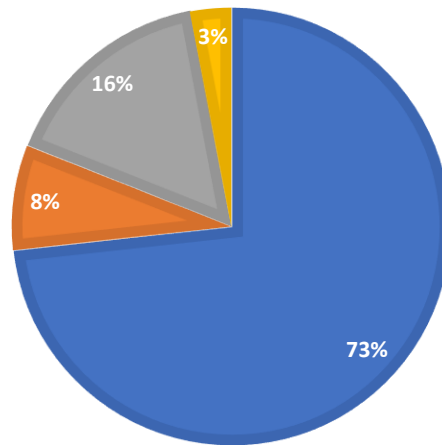
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Source: National Communication (2022)

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 2014

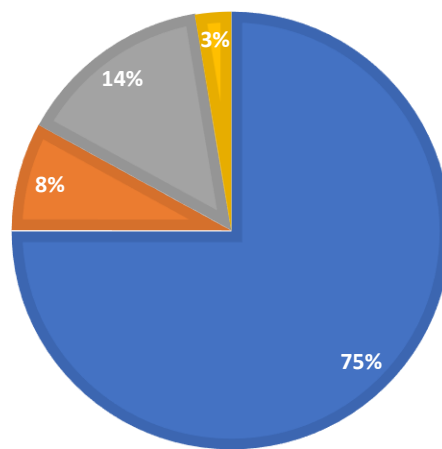
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Source: National Communication (2022)

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 2016

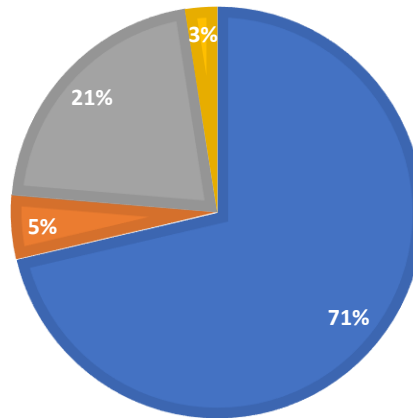
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Source: National Communication (2022)

PERCENTAGE EMISSION OF GREENHOUSE GASES FROM DIFFERENT SECTORS IN 2019

■ Energy ■ Industrial Processes ■ Agriculture ■ Waste



Source: World Resources Institute

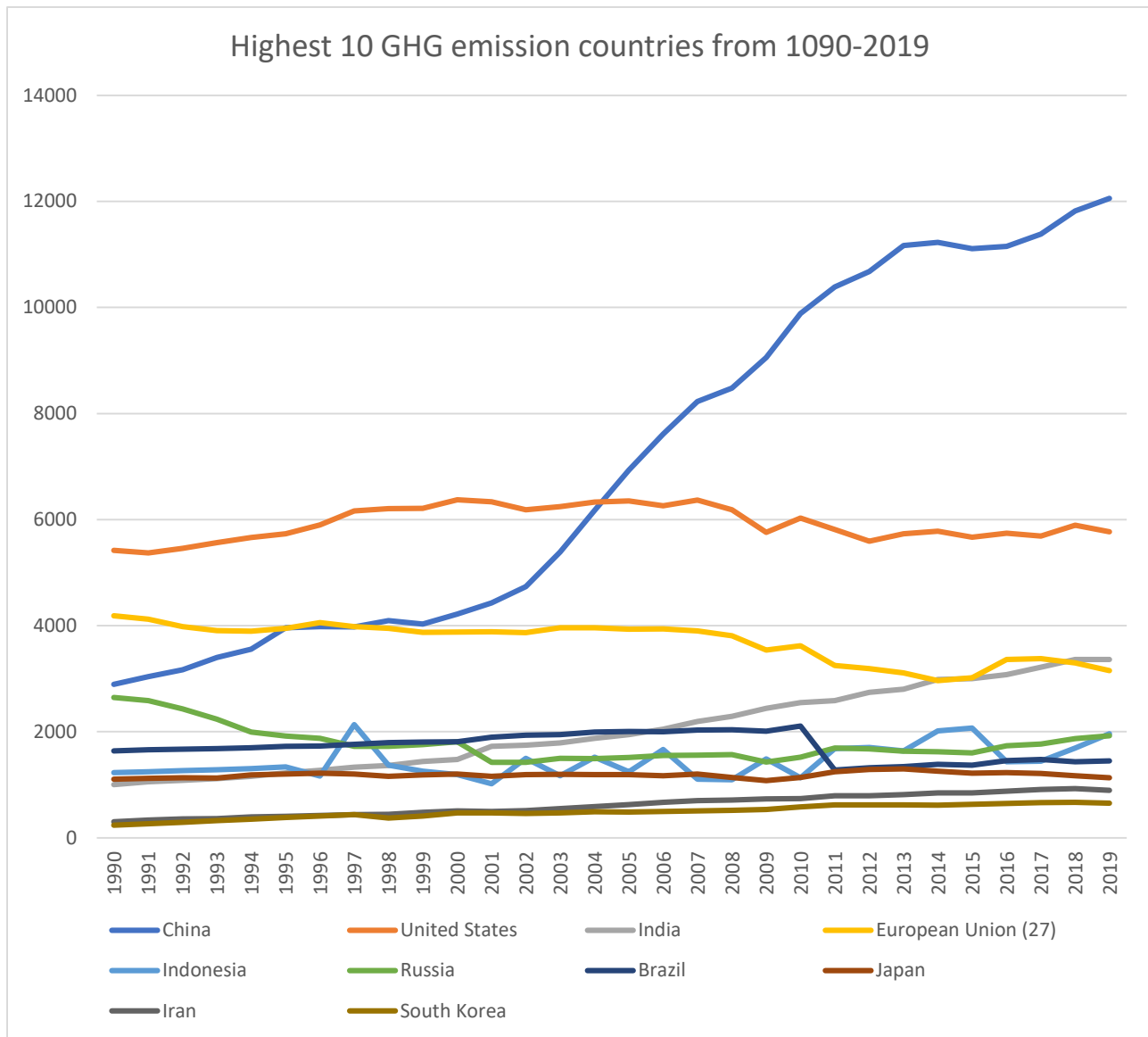
Top GHG Emitting Countries- Carbon dioxide emissions are the dominant driver of climate change. These began rising during the Industrial Revolution which means richer countries like the United States, which made an early transition to a heavily fossil fuel-based economic system, have an outsized role in contributing to the climate impacts we see around the world today.

Greenhouse gas (GHG) emissions responsible for climate change. About 60% of GHG emissions come from only 10 countries, while the 100 least-emitting contributed less than 3%. Energy makes up nearly three-quarters of global emissions, followed by agriculture. Within the energy sector, the largest emitting sector is electricity and heat generation, followed by transportation and manufacturing. Land use, land use-change and forestry (LULUCF) are both a source and sink of emissions and key sector to get to net-zero emissions.^[10]

Table-1 Highest 10 GHG emission countries from 1090-2019^[10]

| Year\ | China | United States | India | European Union (27) | Indonesia | Russia | Brazil | Japan | Iran | South Korea |
|-------|----------|---------------|---------|---------------------|-----------|---------|---------|---------|--------|-------------|
| 1990 | 2891.73 | 5417.32 | 1002.56 | 4187.9 | 1226.82 | 2648.36 | 1638.68 | 1106.26 | 304.22 | 238.32 |
| 1991 | 3039.14 | 5372.07 | 1056.25 | 4120.94 | 1246.27 | 2585.28 | 1659.83 | 1121.71 | 332.58 | 266.53 |
| 1992 | 3168.05 | 5456.12 | 1081.28 | 3981.08 | 1266.98 | 2428.18 | 1669.79 | 1134.81 | 354.38 | 291.96 |
| 1993 | 3397.8 | 5567.55 | 1114.22 | 3908.95 | 1282.35 | 2233.86 | 1681.12 | 1128.24 | 362.41 | 323.65 |
| 1994 | 3557.37 | 5661.57 | 1158.48 | 3894.63 | 1302.7 | 1995.87 | 1697.94 | 1185.98 | 394.82 | 351.89 |
| 1995 | 3960.7 | 5729.69 | 1223.65 | 3947.64 | 1339.1 | 1918.33 | 1724.55 | 1201.33 | 405.33 | 384.86 |
| 1996 | 3982.11 | 5901 | 1272.74 | 4058.46 | 1164.23 | 1874.95 | 1729.84 | 1216.15 | 420.32 | 412.98 |
| 1997 | 3977.65 | 6160.86 | 1331.88 | 3983.29 | 2134.8 | 1723.24 | 1761.29 | 1204.17 | 439.31 | 438.91 |
| 1998 | 4095.97 | 6208.83 | 1362.33 | 3949.25 | 1366.9 | 1725.07 | 1796.63 | 1157.78 | 441.72 | 373.64 |
| 1999 | 4028.58 | 6210.12 | 1440.38 | 3874.4 | 1258.63 | 1759.66 | 1807.27 | 1184.1 | 479.36 | 411.56 |
| 2000 | 4221.08 | 6372.54 | 1477.87 | 3877.33 | 1190.41 | 1812.87 | 1809.18 | 1200.81 | 507.02 | 469.57 |
| 2001 | 4430.04 | 6335.1 | 1725.86 | 3884.4 | 1018.47 | 1423.46 | 1897.8 | 1156.68 | 497.59 | 468.7 |
| 2002 | 4736.95 | 6182.64 | 1744.38 | 3871.02 | 1500.73 | 1422.39 | 1932.79 | 1189.23 | 512.73 | 461.26 |
| 2003 | 5387.28 | 6245.34 | 1787.88 | 3960.54 | 1168 | 1498.74 | 1946.72 | 1197.12 | 548.91 | 469.04 |
| 2004 | 6172.83 | 6331.91 | 1876.85 | 3962.83 | 1517.63 | 1491.42 | 1993.39 | 1188.83 | 585.5 | 492.96 |
| 2005 | 6934.85 | 6352.14 | 1948.11 | 3935.61 | 1245.04 | 1513.85 | 2006.42 | 1190.09 | 624.34 | 488.31 |
| 2006 | 7614.35 | 6260.2 | 2045.4 | 3936.29 | 1664.11 | 1553.64 | 1998.22 | 1168.68 | 667.21 | 496.62 |
| 2007 | 8224.19 | 6367.28 | 2191.17 | 3903.15 | 1107.1 | 1559.85 | 2032.89 | 1204.37 | 703.12 | 506.54 |
| 2008 | 8480.5 | 6184.08 | 2289.14 | 3811.63 | 1093.88 | 1570.09 | 2036.16 | 1137.35 | 711.29 | 519.43 |
| 2009 | 9055.11 | 5757.6 | 2438.92 | 3540.97 | 1487.25 | 1427.44 | 2009.23 | 1078.7 | 734.4 | 533.37 |
| 2010 | 9887.06 | 6026.14 | 2546.79 | 3619.79 | 1131.73 | 1521.96 | 2109.66 | 1136.62 | 737.61 | 585.4 |
| 2011 | 10388.48 | 5811.96 | 2584.75 | 3250.07 | 1683.13 | 1693.95 | 1276.46 | 1243.96 | 793.62 | 619.12 |
| 2012 | 10675.66 | 5593.24 | 2740.4 | 3188.85 | 1702.3 | 1674.58 | 1319.48 | 1286.53 | 793.95 | 622.55 |
| 2013 | 11168.26 | 5734.28 | 2804.34 | 3109.55 | 1638.39 | 1633.1 | 1344.89 | 1298.56 | 815.31 | 622.99 |
| 2014 | 11228.48 | 5779.53 | 2984.52 | 2962.68 | 2015.5 | 1621.85 | 1384.99 | 1256.16 | 844.13 | 612.48 |
| 2015 | 11108.86 | 5665.2 | 3003.07 | 3019.49 | 2067.75 | 1602.81 | 1366.89 | 1220.73 | 844.14 | 633.4 |
| 2016 | 11151.31 | 5743.85 | 3076.48 | 3364.77 | 1434.45 | 1733.91 | 1455.86 | 1229.82 | 881.05 | 648.88 |
| 2017 | 11385.48 | 5689.61 | 3215.07 | 3379.38 | 1447.22 | 1769.68 | 1475.82 | 1214.59 | 912.77 | 662.63 |

| | | | | | | | | | | |
|------|----------|---------|---------|---------|---------|---------|---------|---------|--------|--------|
| 2018 | 11821.66 | 5892.37 | 3360.56 | 3295.53 | 1692.36 | 1868.15 | 1434.51 | 1172.32 | 925.58 | 669.7 |
| 2019 | 12055.41 | 5771 | 3363.59 | 3149.57 | 1959.71 | 1924.82 | 1451.63 | 1134.45 | 893.78 | 652.66 |



Methods of reducing the Greenhouse gases emission: - As earlier seen the major contribution of greenhouse gases emission is from power generation sector. By finding the alternate renewable energy sources the emission of GHG may be reduced. Few alternate renewable energy sources in India are given below-

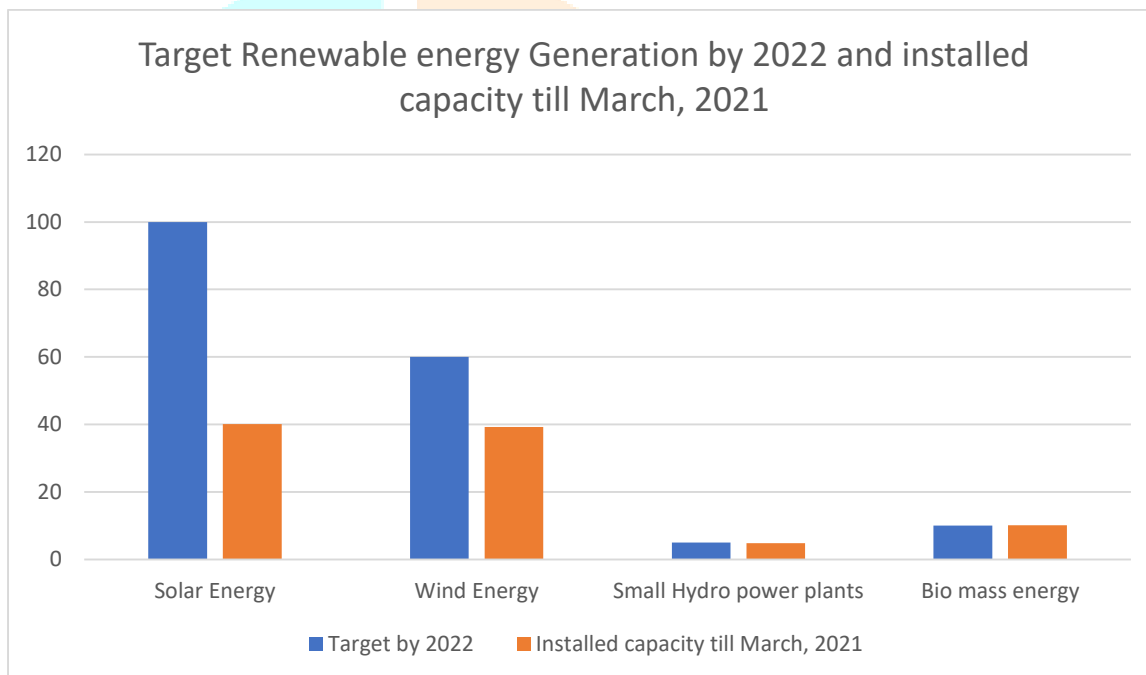
Solar Energy- The Sun has been worshiped as a life-giver to our planet since ancient times. The industrial ages gave us the understanding of sunlight as an energy source. India is endowed with vast solar energy potential. Solar energy has taken a central place in India's National Action Plan on Climate Change with National Solar Mission as one of the key Missions. National Solar Mission (NSM) was launched on 11th January, 2010. NSM is a major initiative of the Government of India with active participation from States to promote ecological sustainable growth while addressing India's energy security challenges. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. The Mission targets installing 100 GW grid-connected solar power plants by the year 2022. In order to achieve the above target, Government of India have launched various schemes to encourage generation of solar power in the country like Solar Park Scheme, VGF Schemes, CPSU Scheme, Defence Scheme, Canal bank & Canal top Scheme, Bundling Scheme, Grid Connected Solar Rooftop Scheme etc. Till March, 2021 the installed capacity of solar power plant in India is 40.1GW.^[4]

Wind Energy- India's wind energy sector is led by indigenous wind power industry and has shown consistent progress. The target wind energy generation is 60GW by the year 2022. The country currently has the fourth highest wind installed capacity in the world with total installed capacity of 39.25 GW (as on 31st March 2021)^[5]

Small Hydro Power Plants- Hydro power projects are classified as large and small hydro projects based on their sizes. In India, hydro power plants of 25MW or below capacity are classified as small hydro power plants. The target energy generation from small hydro power plants is 5GW by the year 2022. Till March, 2021 the installed capacity of small hydro power plant in India is 4.8GW.^[6]

Bio Energy- Biomass has always been an important energy source for the country considering the benefits it offers. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in the rural areas. Biomass is also capable of providing firm energy. The target energy generation bio mass is 10GW by the year 2022. Till March, 2021 the installed capacity of bio mass energy in India is 10.1GW, this is the greater than target energy generation from bio mass.^[7]

The renewable energy sources are helping in the sustainable development of any country. The total targeted power generation from renewable energy sources is 175GW by the year 2022. The total installed power generation capacity from renewable sources is 94.25GW by the March, 2021. During the period from April 2014 to January 2021, the installed renewable energy capacity of India has increased by two-and-half times, and in the same period, the installed solar energy capacity has increased 15 times. Globally, today India stands 4th in RE power capacity, 4th in Wind power, and 5th in Solar Power capacity.^[8]



The annual growth in power generation during recent years-

Table-2 The annual growth in power generation during recent years^[9]

| YEAR | Growth in Fossil Fuel Generation (%) | Growth in Renewable Generation (Including Hydro) (%) | Growth in Non-Fossil Fuel Generation (RE + Nuclear) (%) | Growth in Total Generation (%) |
|---------|--------------------------------------|--|---|--------------------------------|
| 2011-12 | 6.6% | 17.5% | 18.30% | 9.14% |
| 2012-13 | 7.3% | -5.9% | -4.78% | 4.46% |
| 2013-14 | 4.2% | 10.0% | 9.05% | 5.23% |
| 2014-15 | 10.8% | 1.3% | 1.91% | 8.84% |
| 2015-16 | 7.5% | -1.8% | -0.97% | 5.69% |
| 2016-17 | 5.3% | 8.9% | 7.68% | 5.80% |
| 2017-18 | 4.3% | 11.1% | 9.55% | 5.35% |
| 2018-19 | 3.4% | 14.3% | 12.09% | 5.19% |
| 2019-20 | -2.7% | 12.7% | 13.99% | 0.95% |
| 2020-21 | -1.0% | 2.1% | 0.86% | -0.52% |
| 2021-21 | 7.96 % | 7.74 % | 7.96% | 7.96% |

| | | | | |
|----------|---------|---------|---------|---------|
| 2021-22* | 15.04 % | 26.92 % | 22.58 % | 16.71 % |
|----------|---------|---------|---------|---------|

(*upto May 2022)

In 2022 the growth in the renewable energy generation is increased by 26.92%. After COVID period the Government of India is more focusing on the generation of renewable energy that results in the decreased in the emission of greenhouse gases and helps in the sustainable development of India.^[9]

Conclusion- The emission of GHGs from different sectors and different countries are continuously increasing. There are adverse effects of GHG emission on climate. The Earth's temperature is continuously rising. To control the emission of GHG the renewable energy sectors are playing major role. Different countries are focusing on the generation of renewable energy resources that results in the reduction in GHG emission and helps in the sustainable development in the country. It can be accepted that renewable energy technologies may significantly cover the electricity demand and helps in the reduction of emission of GHG. In recent years, the country has developed some policies and focused on the generation of renewable energy. The awareness of saving energy has been promoted among citizens to increase the use of solar, wind, biomass, waste, and hydropower energies. But the renewable energy sectors facing notable obstacles. Some of them are the cost of installation is high, inherent in every renewable technology, required large area.

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