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BEYOND FOSSIL FUELS: THE DAWN OF RENEWABLE ENERGY IN THE POWER SECTOR

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Abstract : Developing nations confront enormous and difficult challenges in finding ways to meet their energy requirements for economic development that are both environmentally and financially sustainable. Power being the utmost aspect of the energy sector requires new innovations to meet the increasing demand for power supply while combating greenhouse gas emissions (GHG's). India is the third largest consumer of energy subjected to rising incomes and upgraded standard of living. With 421.902 GW of installed power generation capacity, India is composed of 237.929 GW of fossil fuels-based (Coal, Lignite, gas and Diesel), 46.85 GW of massive hydro, 7.48 nuclear energy and roughly 129.643 GW of renewable energy sources such as solar energy, wind energy, etc (Ministry of Power, June,2023). This study will try to depict the transition of energy from conventional sources to non-conventional sources in the past two decades. Policy implications and government role will also be studied to understand the push factors of renewable energy adoption. Budget allocations and international assistance will also be examined.

Keywords: *energy, renewable energy, power infrastructure, power subsidies*

"Mitigating global warming will need major transitions or shift in the energy sector and it will mean drastic reduction of fossil fuel use, widespread electrification for all, improvement in energy efficiency, and the use of alternative fuels"

-Intergovernmental Panel on Climate Change **(IPCC)**.

1. Introduction

The world has stepped into a new era of energy, and in addition to clothes, food, and shelter, the essentials of life also include energy, a fourth essential. The most adaptable energy source is electricity, which has the advantage of being easily transmitted and having a high conversion efficiency for use (Bhargava and Gupta, 2005). India's energy consumption is expected to grow quickly and power plays a very crucial role in the financial advancement process and is one of the main drivers of economic development. Energy has a negative impact on the environment in addition to advancing social and economic progress. In the year 2000, carbon dioxide emission was 23847.9 million tonnes which has increased to 32284.1 million tonnes in 2020 ("Statistical Review of World Energy,2021"). India accounts for 6.4% of all carbon dioxide emissions worldwide (IEA,2019). Savings, welfare, and financial improvement depend on a steady, predictable, and moderate electricity supply. The easily accessible and available power feeds the engine of monetary development (Singh and Kaur, 2020). There has been a transition from fossil fuel-based energy to renewable energy in the past few decades. In the year 2000, there were merely 2.64 exajoules of renewable energy consumption which has increased to 31.71 exajoules in the year 2020 ("Statistical Review of World Energy,2021"). The concept of sustainable development was adopted by almost all the countries in the world where new, innovative, and cleaner fuels are considered over conventional ones. In India, per capita consumption of electricity is increasing which was 567 KWh in 2002-03, and has now increased to 1255 kWh in 2021-2022 (Central Electricity Authority) with rising Gross Domestic Product (GDP). This study will represent a shift from non-renewable energy sources to renewable energy sources in India along with its impact on the environment. Government schemes and policies to promote non-conventional sources of energy will also be presented and financial subsidies from the public sector and external financial aid for cleaner sources of energy will also be discussed.

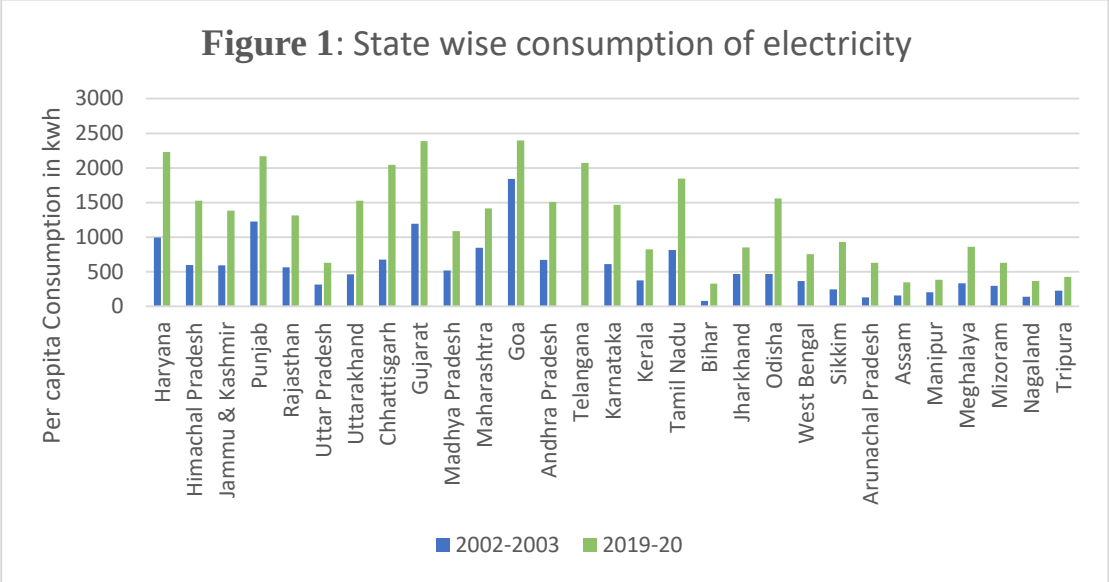
2. Literature Review

Nasir et al**. (**2021) using the Long-Range Energy Alternative Planning (LEAP) System estimated the amount of electricity that Punjab will need in 2050 based on a comparison of four supply scenarios: Business as Usual (BAUS), Coal (CS), Oil (OS), and Green Punjab Scenario (GPS). Study concluded that the state will need 279.7 TWh of electricity. In BAUS, CS, OS, and GPS, the corresponding greenhouse gas emissions will be 45.5, 58.3, 55.0, and 24.1 million metric tonnes of carbon dioxide equivalent. Green

Punjab Scenario's energy generation was the least expensive and produces less than 50 percent of GHG emissions from other scenarios. Ek (2005) conducted a primary survey on Swedish households in order to effectively track the growth in renewable capacity emphasising on wind energy. Through mailed questionnaires, samples of 655, 1200, and 1000 homes were gathered. The factors that influence the spread of wind energy were examined, and the connections among cost generation, cost reduction, and diffusion were evaluated. A behaviour model that maximises utility has been applied. Variations in consumer attitudes were investigated using variables such as gender, income, educational attainment, and environmental preferences. Additionally, pooled annual time series data covering the years 1986–2001 for five European nations—Denmark, Germany, Spain, Sweden, and the United Kingdom—was taken into consideration. The findings indicated that a key factor contributing to the increased spread of wind power was a decrease in investment. Learning by experience provided an explanation for cost savings. Carfora et al. (2018) looked at the factors that went into deciding to create an energy policy that supported renewable energy sources. The findings showed that public operational variables were more active in poorer nations, suggesting a significant role for government policies. To determine which approaches were suitable for quantifying the cost of capital estimation for renewable energy projects, Steffen (2020) carried out an empirical study. Data from the financial markets was analysed, and the weighted average cost of capital (WACC) was computed. The findings showed that the cost of capital investment rises with increasing levels of solar PV, onshore wind, and offshore wind generation. When comparing the cost of capital between industrialized and developing nations according to their respective levels of economic development, emerging nations generally had far higher costs. Venkatraja (2019) investigated the impact of fluctuations in the proportion of renewable energy in the overall energy blend of the BRIC nations using secondary data from 1990 to 2015 using a panel regression model. Per capita GDP when regressed on the fraction of renewable energy use and renewable power output, showed that increasing the proportion of renewable energy in the overall energy mix in the BRIC countries will negatively affect economic growth rates and vice versa. It has been discovered that the switch from conventional to renewable energy is not always seamless and might lead to economic imbalances within a country as a result of the associated costs. Thus, we can see that various studies have shown the effects of renewable energy on growth. We are studying the decadal growth of renewable energy sources in India.

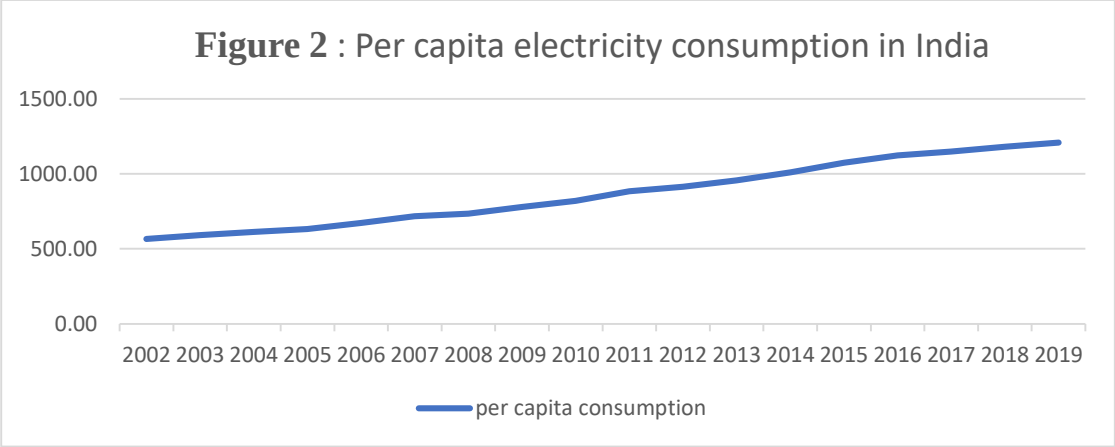
3. Data and methodology

Descriptive statistics have been used in this study to show the change or shift in energy consumption, carbon dioxide emission and share of renewable energy consumption in India. Secondary data of 20 years that is from 2001 to 2020 has been utilised for this study. Let us first see the shift in per capita consumption of energy state wise in India.



Source: cea.nic.in

In the above diagram we can clearly see how the per capita consumption for all Indian states has increased. The Compound Annual Growth Rate for India is 4.29%.



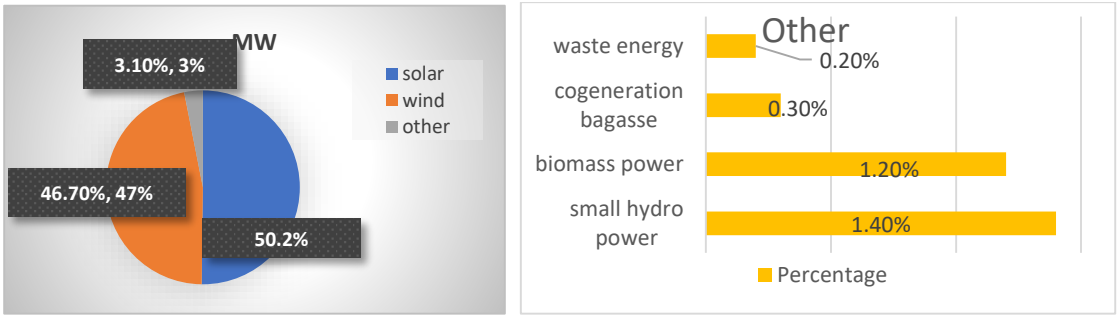
Source: cea.nic.in

With a population of 1.4 billion, India has a rapidly expanding economy with a growth rate of 8.71 percent (World Bank, 2021). The majority of power is produced by conventional energy sources, of which coal is the most significant fossil fuel and accounts for the largest part (74 percent) (Statistical Review of World Energy 2021"). The second most common conventional source is oil, which ranks third globally in terms of

oil consumption. It accounts for 28% of all energy consumption and produces 0.1% of the world's electricity ("Statistical Review of World Energy, 2021–India"). Natural gas is the third energy source, accounting for 3.7% of India's power output and 6.3% of the country's overall energy consumption ("Statistical Review of World Energy, 2021–India"). India has been actively combating climate change since the 2015 Paris Agreement and the Glass-Glass commitment of 2021. The country has set goals to lower emission intensity and increase the proportion of non-fossil fuels used in power generation. India intends to increase its capacity for non-fossil fuel energy to 500 gigawatts by 2030, achieving 50% of its energy needs from renewable sources. It also plans to reduce its carbon footprint by 1 billion tonnes, lower its carbon intensity to less than 45%, and achieve net zero emissions by 2070. Although India has lowered its GDP's emission intensity in accordance with its aims, supplying power with low carbon emissions remains a difficulty. India held its third position on the Country Attractive Index (RECAI) in October 2021. India has done a good job of embracing renewable energy sources in recent years, and in October 2021, it maintained its third place on the Earnest & Young (EY) Renewable Energy Country Attractive Index (RECAI).

India is ranked fifth in the world for solar power capacity, fourth for wind power, and fourth for renewable energy (Indian Brand Equity Foundation, 2022). The primary non-conventional (or renewable) energy sources are biomass, nuclear energy, geothermal, wind, hydro, and solar energy. 10.3% of India's consumption is non-conventional ("Statistical Review of World Energy, 2021–India"). With the largest percentage of non-conventional sources, or 50.20 percent, solar energy is the most significant renewable energy source in India (GOI, 2022).

Fig 3: Renewable energy of India: Source wise: (Estimated potential as on 31-3-2021):



Source: Energy statistics India 2022 (GOI,2022)

In the above figure clearly, we can see that in renewable energy, solar energy has the highest potential i.e. 50.2 percent followed by wind energy (46.7 percent) and others (3 percent). Transitioning from the current fossil fuel-based energy system to a power-efficient and renewable economy is an important milestone for a more secure, resilient, economical, and sustainable energy future, particularly in the power sector (REN21, 2022). Increasing local renewable energy output combined with energy savings and increased energy efficiency boost energy security, autonomy, and diversification. In addition to reducing emissions and producing other financial benefits, this lessens exposure to fluctuations in energy prices (Stern, 2004).

Table 1: Growth of renewable consumption in India from the year 2000 to 2020.

Year	2000	2001	2002	2003	2004	2005	2006
Consumption in exajoules	**0.03**	0.04	0.07	0.08	0.11	0.13	0.18
Year	2007	2008	2009	2010	2011	2012	2013
Consumption in exajoules	0.22	0.26	0.30	0.36	**0.44**	0.50	0.56
Year	2014	2015	2016	2017	2018	2019	2020
Consumption in exajoules	0.63	0.65	0.79	0.95	1.18	1.33	**1.43**

Source: BP Statistical Review of World Energy 2021

We can configure from Table 1 that gradual increase of renewable consumption in India can be observed. The Compound Annual Growth Rate is 20.20%.

Table 2 : Growth of renewable generation through solar energy in India from the year 2007 to 2020

Year	2007	2008	2009	2010	2011	2012	2013
Generation in terawatt hours	0.1	0.1	0.1	0.1	**0.8**	2.1	3.4
Year	2014	2015	2016	2017	2018	2019	2020
Generation in terawatt hours	4.9	6.6	11.6	21.5	36.3	46.3	**58.7**

Source: BP statistical Review of World Energy,2021

In the above table, we can observe that renewable generation through solar energy in India was consistent till 2010 and exhibit change only in 2011 and reached 58.7 terawatt hours in the year 2020. The CAGR is 57.67%. Similarly, consumption of solar energy in 2011 was 0.1 exajoules which increased to 0.52 exajoules in the year 2020 in India with CAGR of 8.59%.

Table 3: Growth of Renewable generation through hydroelectricity in India

Year	2000	2001	2002	2003	2004	2005	2006
Generation in terawatt hours	77	72	68.5	69.3	100.6	97.4	112.6
Year	2007	2008	2009	2010	2011	2012	2013
Generation in terawatt hours	122.6	115.2	106.3	108.7	**131.7**	115.8	132
Year	2014	2015	2016	2017	2018	2019	2020
Generation in terawatt hours	139	133	128.4	135.8	139.8	162	**163.6**

Source: BP Statistical Review of World Energy 2021

In the above table, we can observe that renewable generation through hydroelectricity energy in India has fluctuating trend it reached 163.6 terawatt hours in 2020 from 77 terawatt hours in the year 2000. The CAGR is 3.65%. Similarly, consumption of hydroelectricity in 2000 was 0.77 exajoules which increased to 1.45 exajoules in the year 2020 in India with CAGR of 3.05%.

Table 4 : Growth of renewable generation through wind energy in India

Year	2000	2001	2002	2003	2004	2005	2006
Generation in terawatt hours	1.6	2.1	2.1	2.6	5.2	6	9.3
Year	2007	2008	2009	2010	2011	2012	2013
Generation in terawatt hours	11.7	14.4	16.3	19.5	**24**	27.4	30
Year	2014	2015	2016	2017	2018	2019	2020
Generation in terawatt hours	33.5	32.7	43.5	52.6	60.3	63.3	**60.4**

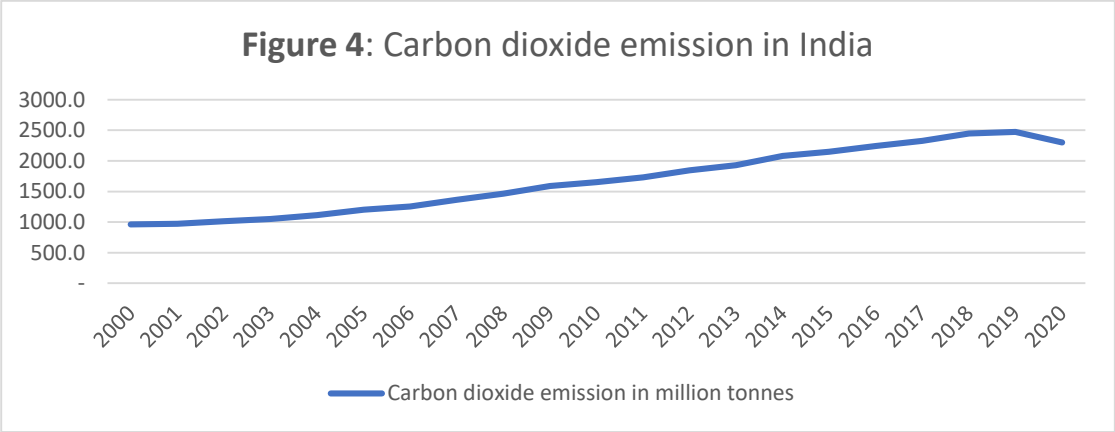
Source: BP Statistical Review of World Energy 2021

In the above table, we can observe that renewable generation through wind energy in India has increased over a period of time. From 1.6 terawatt hrs in the year 2000 to 60.4 terawatt hr in 2020.The CAGR is 18.87 %. Similarly, consumption of wind energy in 2000 was 0.02 exajoules which increased to 0.54 exajoules in the year 2020 in India with CAGR of 16.99%.

Thus, we have discussed the change in energy generation and consumption pattern of three major renewables in India: solar energy, hydroelectricity and wind energy.

4. Results and discussion

We need clean energy for reduction in carbon dioxide emissions. Carbon dioxide emitted from the process of coal combustion was behind for 33 percent rise in global average annual surface temperatures above pre-industrial levels. This identifies coal as the single largest source of global temperature rise. About 40% of the world's carbon dioxide emissions come from the combustion of fossil fuels to produce the heat needed to run steam turbines, which produces electricity. Carbon dioxide (CO2), the major "greenhouse gas" that traps heat and is mostly to blame for global warming, is produced when fuels are burned. We can lower this pollution from the production of electricity by utilising the smart grid approach.



Source: BP ,2021

In the above diagram we can see that carbon dioxide emission is rising continuously from the year 2000 to 2019. In the year 2020 we can see the declining part due to worldwide lockdown. The CAGR is 4.24%. Over the previous ten years, India's GDP has seen a more than 20% decrease in both its energy and emission intensity. India currently emits 1.6 tonnes of carbon dioxide per person, less than the global average of 4.4 tonnes. (IEA,2019). India is in a positive trajectory of growth with increase in renewable consumption

5. Government role and policy implications

The scarcity of resources, their allocation, and the trade-off between consumption now and consumption tomorrow have been the main concerns for all economies, developed and developing (Thirlwall, 1989). Therefore, achieving sustainable economic growth that raises per capita income is the fundamental economic and social goal of government policy (ibid.). The Reserve Bank of India began providing loans for small-scale renewable energy projects in 2015. In September 2020, the loan limit was increased to Rs

30 crores for households, with an additional Rs 10 lakhs for borrowers (GOI, 2021b). On February 1, Union Finance Minister Nirmala Sitharaman said that the Union Budget 2023 would include Rs 10,222 crore for the renewable energy sector. The expenditure represents a 48 percent rise over the budgeted amount of Rs 6,900.68 crore from the previous year and a 45.3% increase over the revised estimate (RE) of Rs 7,033 crore (GOI, 2023c). There are various schemes of government to promote renewable energy production and consumption to name a few: Biomass Gasification Scheme, solar /Green cities program, UJALA LED bulbs campaign, setting up of national institutes for various renewable energies, IREDA and AREAS, etc.

6. External aid

In order to install solar panels in Indian homes, the World Bank offered 165 million dollars in assistance in 2017. A grant of $648 million has been given to commercial and industrial photovoltaic systems installed on rooftops since 2017 (World Bank, IBRD-IDA, 2022). Out of these 150 million dollars were granted by IBRD (Industrial Bank Of Reconstruction and Development) and 15 million dollars were provided by IBRD fund For innovative global public goods solutions. A $1.5 billion loan from the World Bank has been granted to boost India's low-carbon energy industry (World Economic Forum).

7. Conclusion

The power sector in India is facing numerous problems such as lack of adequate coal supply, Transmission and Distribution losses and consumer level loss of power, theft of power, resistance to energy efficiency in residential building sector and hydroelectric power projects. A right energy mix of renewable and non-renewable resources of energy can lead to more efficient power production. Thus, we can say that India is taking small strides to reach its goal as pledged in the Paris Agreement. Policymakers, researchers, and stakeholders should come together for policy-making of incremental growth of renewable energy in India.

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