



## Transition Towards Renewable Energy

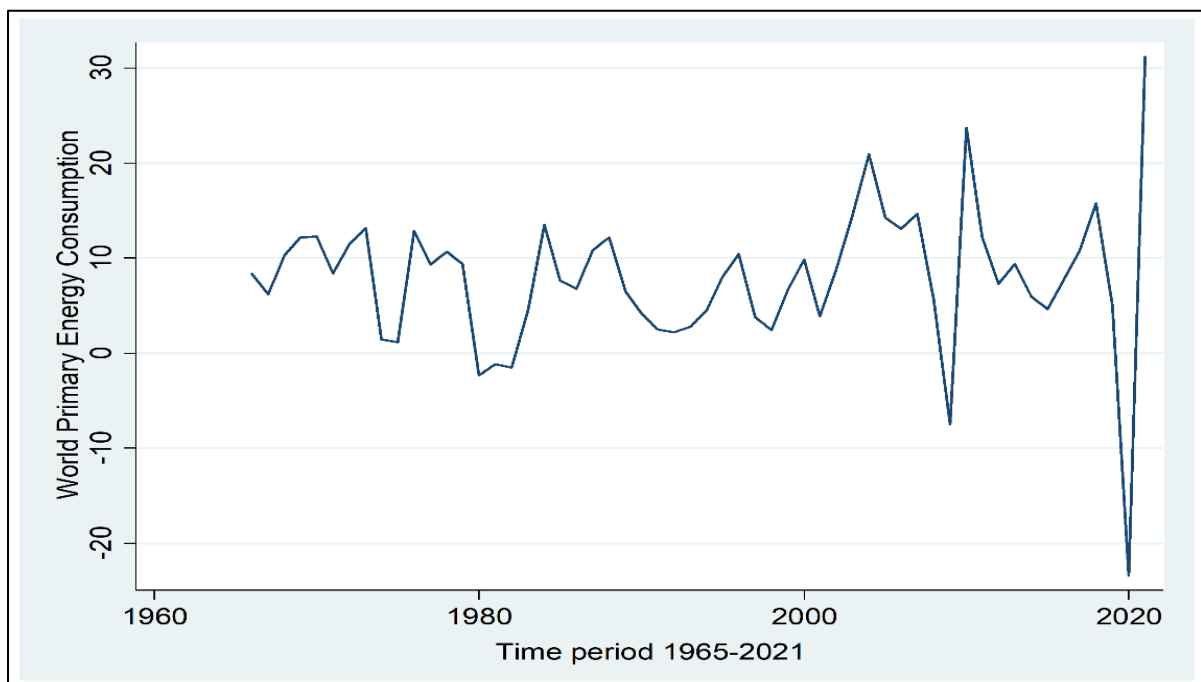


LSI Financial Services Pvt. Ltd.

## Introduction:

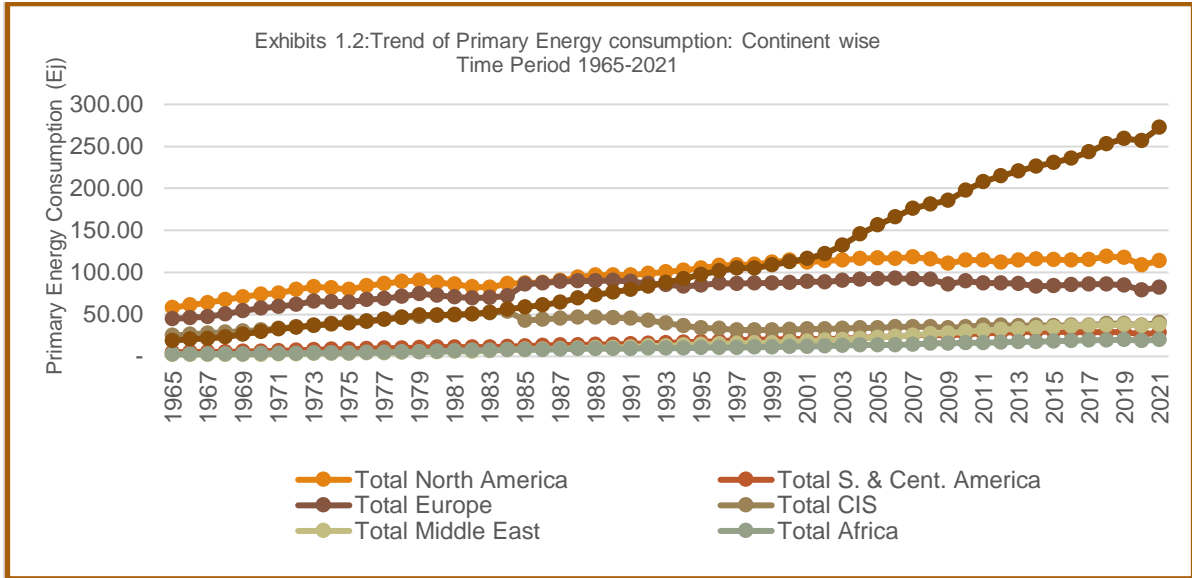
The central problem to the policymakers across the globe currently has been solving the problem of *sustainable development*. Market externalities and failures are constant outcome of the advent of economic growth. One of such external cost is borne by the environment while the energy resources are extracted. Exponential population growth, advancement of technology followed by rapid industrialization and increased urban settlement and development is creating improved energy demand across the world. According to the estimates of US EIA, global energy demand is going to increase by 47% by 2050. Every, single economic activities are not possible without energy, energy is one of the prime factors of production, beside capital, labor, land, materials services and human capital. Wherein in subsistence economy two major factors of production is energy and labor which are essential for satisfying basic human needs. Disruption in the supply of energy is going to severely hamper the economy and society at large. Economic progress of a nation is crucially dependent on sufficient supply of energy. Low income makes unavailability of energy, which in turn depresses productivity and income- leads to poverty trap. Therefore, optimum supply of energy at affordable prices is of principle interest to the policymaking for the well-being of the economy. From exhibit 1.1 it is evident that primary energy consumption has been fluctuating over the time period of 1965-2021, reason being it is functional of the economic activities. With the course of business cycle, demand for primary energy has changed over time. To mention the most prominent fall in demand of energy was in 2008 due to recession because of financial crisis and during the pandemic induced lockdown in 2020.

Exhibits 1.1: World primary energy consumption



Source: LSI Research calculation-based on data from BP-statistics

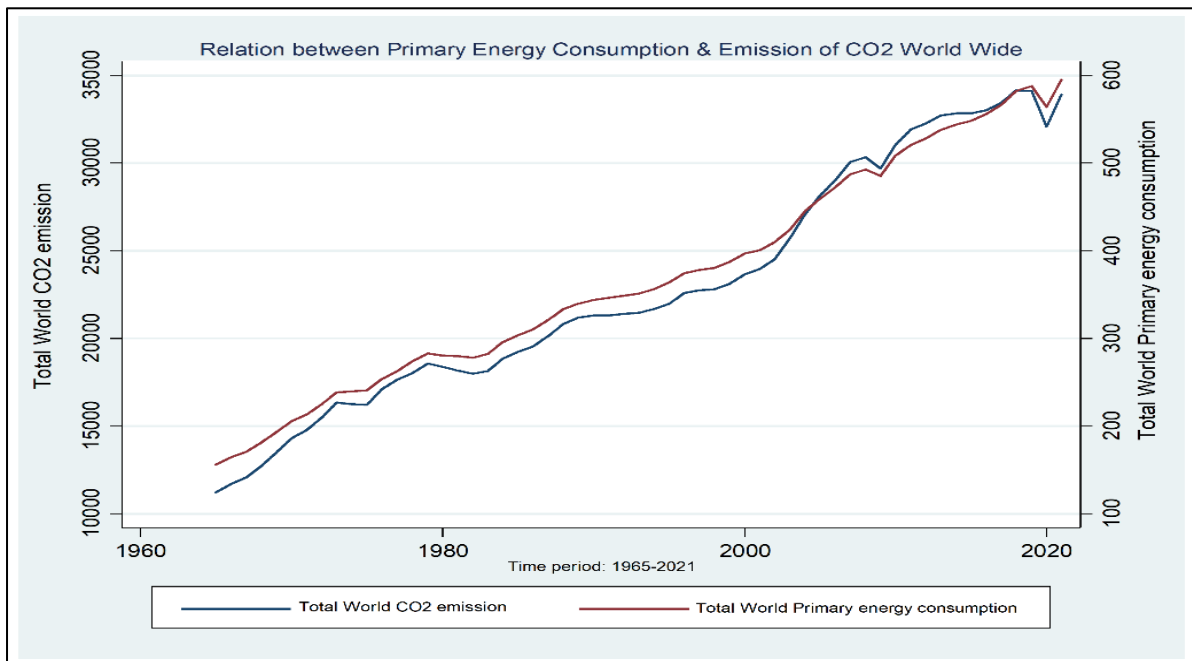




Source: BP statistics; LSI Research

Predominantly the 84% of the global primary energy demand is met by the fossil fuel sources(non-renewable). Extraction, transformation, transmission and use of energy from fossil fuel sources is associated with negative environmental impacts. Energy sector has been the largest in terms of emission of carbon and polluting air, water and soil. These negative effects on environment are negative externalities in economic terms. The negative cost associated with the use of non-renewables brings in inefficiency in the market. The impact of the depletion of fossil fuel, the emission of greenhouse gases and risk of climate change puts forward the question on intergenerational justice and thus raises the issue of *sustainable development in a world of overlapping generation*. Therefore, the decision concerning the optimal extraction of fossil fuel and usage of energy from it, is of dynamic in nature from the perspective of inter-generational interest.

Exhibits 1.3: Relation between Primary Energy Consumption Carbon Emission World-Wide



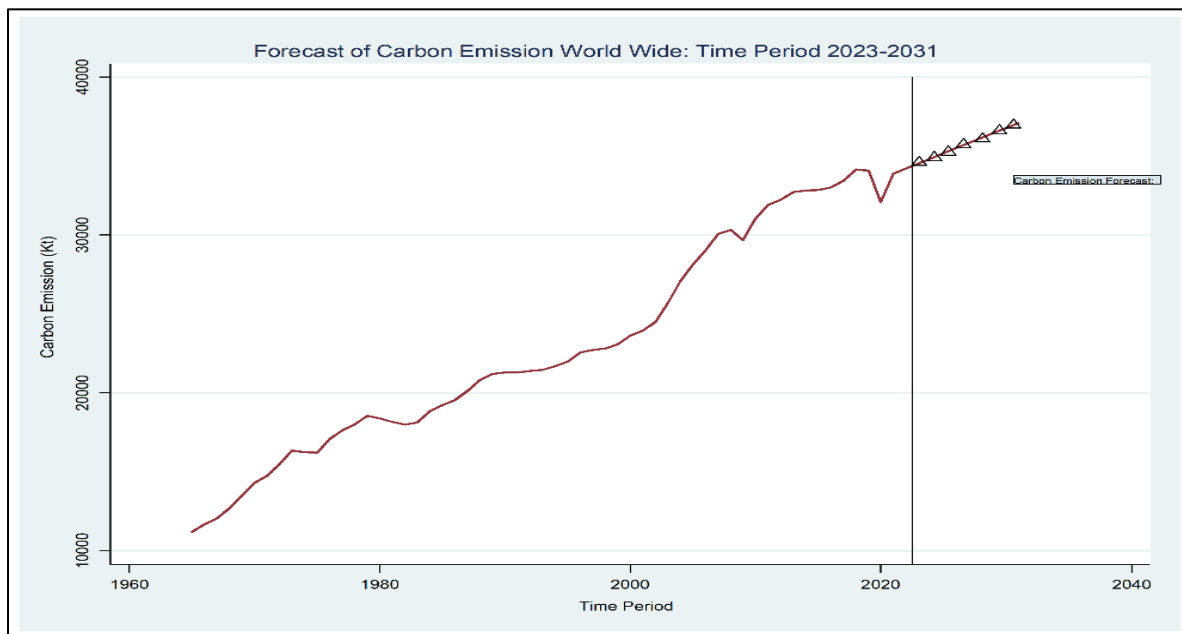
Source: BP statistics; LSI Research



Increase in carbon footprint with increase in primary energy consumption has been quite trivial since majority of the primary energy comprises of fossil fuel sources. In exhibit 1.3 it is visible from that carbon emission has been always directly proportional of the consumption primary energy. An intriguing observation is found in the period of 2001-2019 when the carbon footprint has surpassed the primary energy consumption. During the start of the decade of 2000 the world economic growth took a higher trajectory and more than proportionately carbon emission has also increased during that particular period.

The empirical analysis conforms that carbon emission is directly proportional with the growth of primary energy consumption world-wide. It is estimated that carbon emission is positively affected by 71% percent over a unit change in the consumption growth of primary energy. Carbon emission is inversely related with growth of world GDP. With the growth of the world GDP a share is spent on the abatement cost for environmental protection, but the magnitude of spending is far low than the optimal amount, which is conform by statistical insignificance from the analysis.

Exhibits 1.4: Carbon Emission Forecast World-Wide



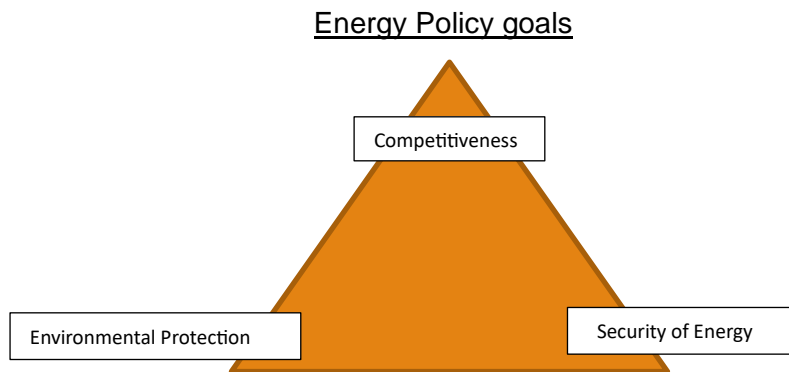
Source: LSI Research calculation based on data from BP-statistics

Negative externalities can be reduced by saving energy and increasing the efficiency of energy usage. But both demand and supply of investment for energy efficiency is constrained by many distortions- *The energy infrastructure involving planning and operations also has a gestation period cost associated. The demand for energy is predicted over a long horizon and that too with some percentage of error and this leads to excess capacity and hence increasing the cost.*

**Global economy is currently facing the twofold challenge of fulfilling the growing energy demand and, reducing the green-house gas emission and improve energy efficiency. The singular approach to make the situation conducive and meet both the ends is usage of renewable energy.** Renewable energy could be effective in environmental protection, energy security and could also play a significant role in creating various kind of new employment opportunities. Many countries have framed their energy policies



incorporating renewable energy and reducing carbon emission in due process. National policies of many countries have given strategic importance to the development of renewable energy technology and increasing the install capacities. At present internationally, the energy system is going through the transition process from fossil energy to renewable energy to reach the sustainable development goals. One of the ways to reduce the carbon emission and improve efficiency of the energy system is by increasing the share of renewable energy in generating electricity.



Globally the preferred choices have been towards the technologies of low carbon footprints and re-course of public financing has been in that respective direction. But many renewable energy technologies are of very high cost, which in turn is caused by low energy density, and renewable energies are also not fully competitive. However, they may become competitive in future, when the prices of the exhaustible resources are bid up. The adoption of renewable energy by the consumer may grow rapidly if government can subsidise the cost of adoption. Moreover, discontinuous supply of renewable energy also makes under-utilization of the installed capacities causing diseconomies of scale for the electricity generation and the distribution companies.

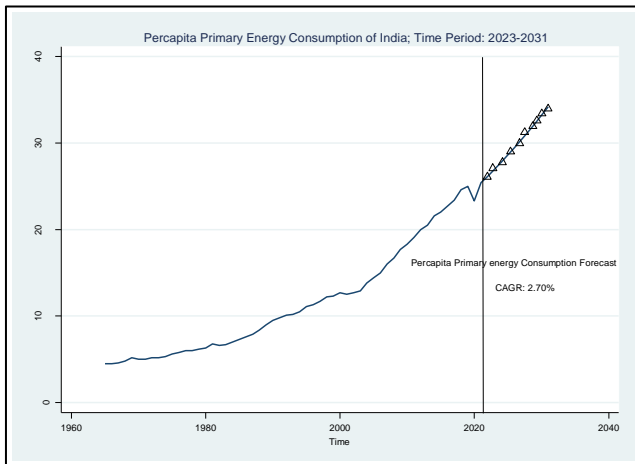
### **India's Energy Scenario:**

India with a population of 1.3 billion is a growing and expanding economy with rapid industrialization and urbanisation. A massive energy demand is generated to fuel the growth of the economy and more will be required to sustain a growth rate of 7%-10% to achieve \$5 trillion - \$10 trillion economy by 2030. India currently stands as the third highest consumer of energy in the world. Increase in income and standard of living, is giving rise to consumption of energy in India. According to the estimates of International Energy Agency (IEA), energy usage in India has doubled since 2000 and still 80% of energy demand is met by coal, oil and biomass. Since 2000 India has contributed to 10% of global energy demand and per-capita consumption of energy has increased by 60%. IEA states that per-capita coal demand has increased from 25% in 1990 to 60% in 2019. India has the fifth highest reserve of coal in the world. But nevertheless, India is net importer of fossil fuel in terms of oil and is net price taker in the global oil market, affecting the current account deficit with huge import bill. The oil demand is set to rise more with increase in ownership of vehicles and road transport use.



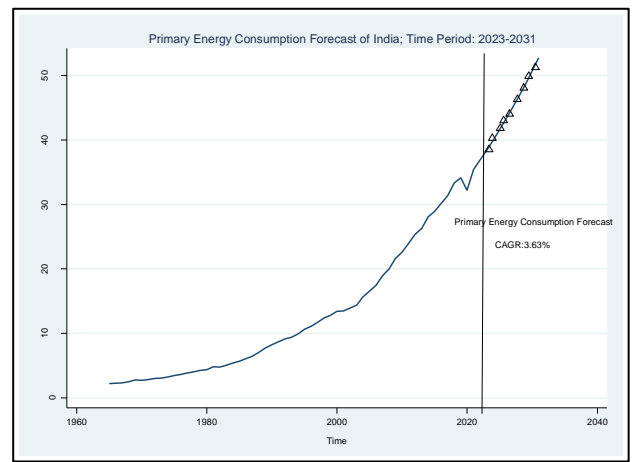
India's growth share is majorly contributed by the service sector for last two decades, which is relatively less energy intensive compared to manufacturing sector, but it is projected to have a moderate urbanisation growth over next two decades with new 270 million people getting added to the urban population, with this addition a surge in demand is going to get generated on the manufacturing sector, especially on the core sectors- cement, iron & steel, roads and other building materials and infrastructure. The supply side economy therefore is going to require a sufficient supply of energy to meet the final demand. Through the linkage effect a possibility of increase in employment and more income also lies ahead in future and followingly there will be rise in consumption demand, resulting in more energy demand.

Exhibit 1.5: Per-Capita Primary Energy Consumption Forecast of India



Source: LSI Research calculation based on data from BP-statistics

Exhibits 1.6: Primary Energy Consumption Forecast of India



Source: LSI Research calculation based on data from BP-statistics

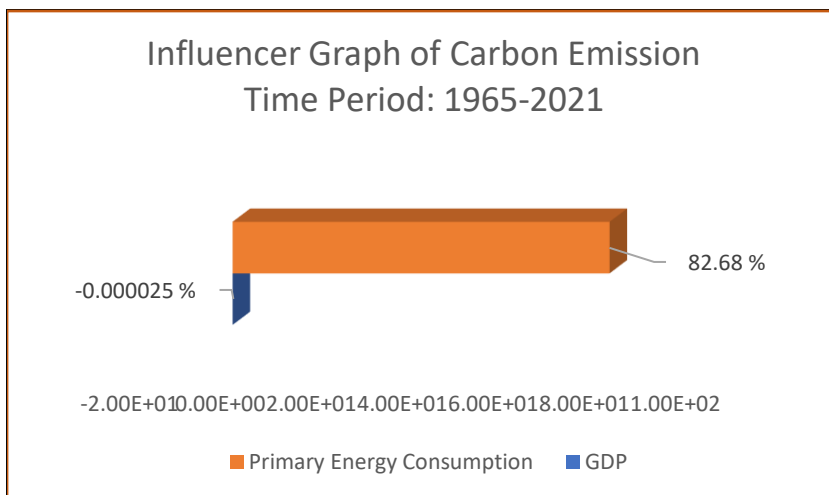
Long run behaviour of per-capita consumption of primary energy and absolute primary energy consumption of India depicted in exhibit 1.5 and exhibit 1.6 respectively, is found to be increasing in accordance with rise in population growth and rapid industrialization, and the exogenous break in trend appeared only during the pandemic year of 2020, and with resumption of economic activities primary energy consumption again had a steep increase thereafter. But rate of increase in consumption of primary energy on absolute basis is more than the per-capita basis. The difference of this particular behaviour is conceived from the fact of stark income inequality present in India and the implication is reflected in the energy usage between different income groups. Incorporating the trend and the structural break, forecasting of per-capita primary energy consumption has been created for the period of 2023-2031 and found to have a CAGR of 2.70% with an increasing trend. Similarly, forecasting of absolute primary energy consumption of India has been created for the time period of 2023-2031 and observed to have a steep rise with a CAGR of 3.63%.



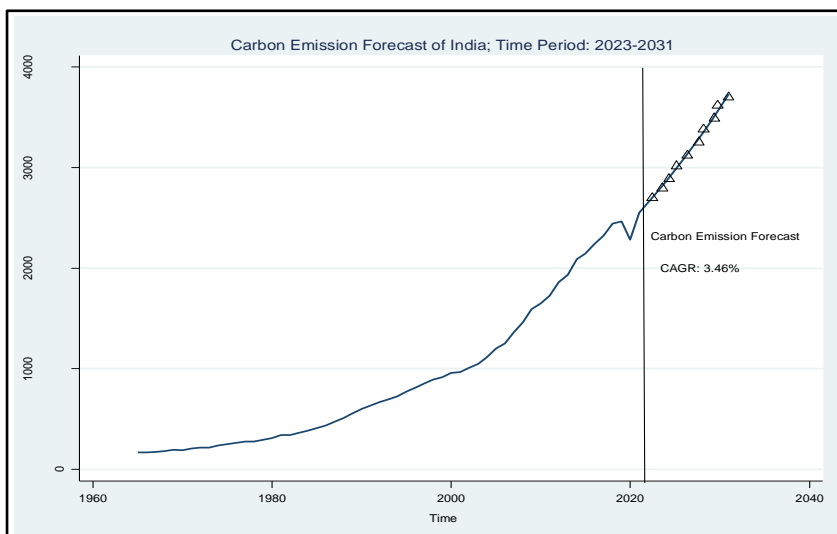
### **Relation Between Carbon Emission, Primary Energy Consumption & GDP in India:**

It has been observed empirically that primary energy consumption in India influences carbon emission positively by 82%. The result is in consonance with the fact that 80% of the energy demand of India is catered by fossil fuel, predominantly coal and oil. Empirically it has been estimated that economic growth (in terms of GDP growth) negatively influences carbon emission, i.e., 1% change in GDP will reduce carbon emission by 0.000025%. It can be deduced from the analysis that with the progression of time as economic growth rises a share of GDP is spent as the abatement cost to protect the environment from greenhouse gas emissions. But the fact is reduction in carbon emission in India is insubstantial, implying the share of GDP spent as abatement cost is not sufficient enough to mitigate the environmental damage caused, and the fact is in conformity with the weak statistical significance surfacing from the analysis.

Exhibit 1.7: Influencer Graph of Carbon Emission in India



Exhibits 1.8: Carbon Emission Forecast of India



*Source: LSI Research calculation based on data from BP-statistics*

In Exhibit 1.8 it is observed that carbon emission has increased over time with increase in economic activity, population growth and rise in urban settlement with passage of time. In the long time series (1965-2021), carbon emission is found to have a steep fall only once during the pandemic induced lockdown period in 2020, and the rate of change of carbon emission



has increased more rapidly since 2000 in tandem with increase in economic activity and growth. Incorporating the data generating process of carbon emission and the influencing factors forecasting of carbon emission has been created for the period of 2023-2031, which is found to have a steep rise with a CAGR of 3.46%. The CAGR of carbon emission and absolute primary energy consumption of India is almost near-to similar, implying the conjunction of the increase in carbon emission and economic activities.

### Major concern for Indian consumer is sufficient supply of energy at affordable prices

But the crucial question is about how to meet the energy demand, because:

- ✓ India is densely populated and with respect to that proportionately resource constrained.
- ✓ Additional impediments that India faces is the perennial problem of poverty, water stress in many regions and land use constraint.

Cutting through these tight socio-economic condition and structural issues- India in near to medium term future has to fulfil the objective of meeting optimal demand for energy and sustainable development goals at the same time.

Income inequality is another structural issue of the Indian economy, and its implications are reflected in the energy usage too. The absolute value in energy demand is growing in India, while the per-capita energy usage is still below the international standard. In align with the skewed energy usage distribution, it is observed that India's annual carbon emission is third highest globally, but per-capita carbon emission is below hundred.

## Renewable Energy:

### In Global Context

Contemporarily major attention in the world is on decarbonization of the energy system to cope with its' challenges-

- ✓ Reducing green-house gas emission to mitigate global climate change,
- ✓ Reducing air pollution locally, and also
- ✓ Enhancing energy security and sufficient energy supply.

The power sector of the world contributes to 75% of carbon emission and responsible for global warming. Transition from one energy to another has happened with stages of economic development- from one fossil fuel energy to another. Today by far fossil fuels- coal, oil and natural gas, are the dominant form of energy for industrial economies and main source of fuelling economic growth in developing economies. *But nevertheless, motivated by climate change and energy security issues, in this 21<sup>st</sup> century the transition towards renewable energy is taking place gradually.* The societal choice of renewable energy over non-renewable energy is developing after understanding fossil fuels are limited in supply and can be developed over a geologic time.





New economic growth models and policy strategies across the globe are designed for the evolution of green market and promoting sustainable development approaches-

- *Energy production from renewable sources is expressed as a production that does not consume natural resources, does not destroy nature and does not pollute the environment with its wastes. Increasing energy production from renewable sources can reduce the use of fossil fuels and thus reduce carbon emissions, providing solutions to many environmental problems. Renewable technologies reduce both the amount of energy and raw materials required for production processes that provide economic growth and the amount of waste generated from production and consumption processes.*
- Globally, the renewable energy as the key input in the production and consumption choices is going to play a pivotal role in accomplishing the objective of Sustainable Development Goals (SDGs). To make our world a better planet, United Nations (UN) have designed the framework and formulated the guidelines for SDGs and urging every member nation to adopt renewable energy and comply with the respective guidelines and framework to accelerate the steps to accomplish the target of meeting the SDGs by 2030. Goal number 12 of SDGs focusses on availability and affordability of clean energy, energy efficiency, sustainable infrastructure, consumption and productions.

Currently about 17.5% of the final energy demand is met by the Renewable energy and the rest is by means of conventional sources- fossil fuels,

leading to chain reaction of GHG emission, global warming and climate change effects.

**Kyoto Protocol (2005) and Paris Agreement (2016) -- two international treaties on environmental protection and climate change that extends the UN framework of Convention on Climate Change (1992).**

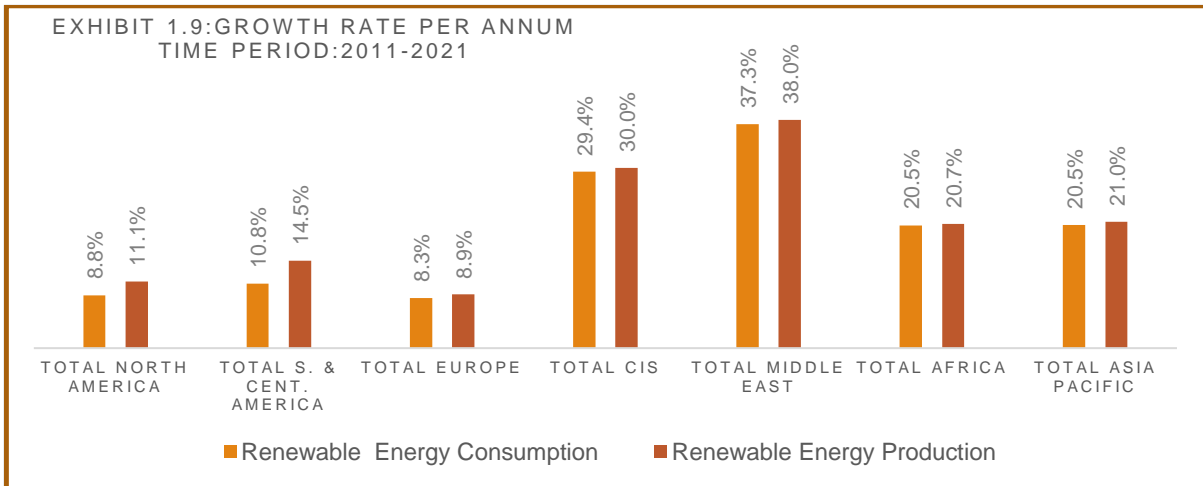
- According to Kyoto Protocol member nations have the binding obligation to reduce carbon emission and reduce the dependency on energy imports (especially natural gas and oil imports).
- One of the primary objectives of Paris Agreement keep the global temperature rise less than 2 degrees Celsius and as of 2019, 197 countries have signed the agreement.

Following the Paris Agreement many member nations have set the target of net-zero emission and investments are driving towards cleaner energy and economy.

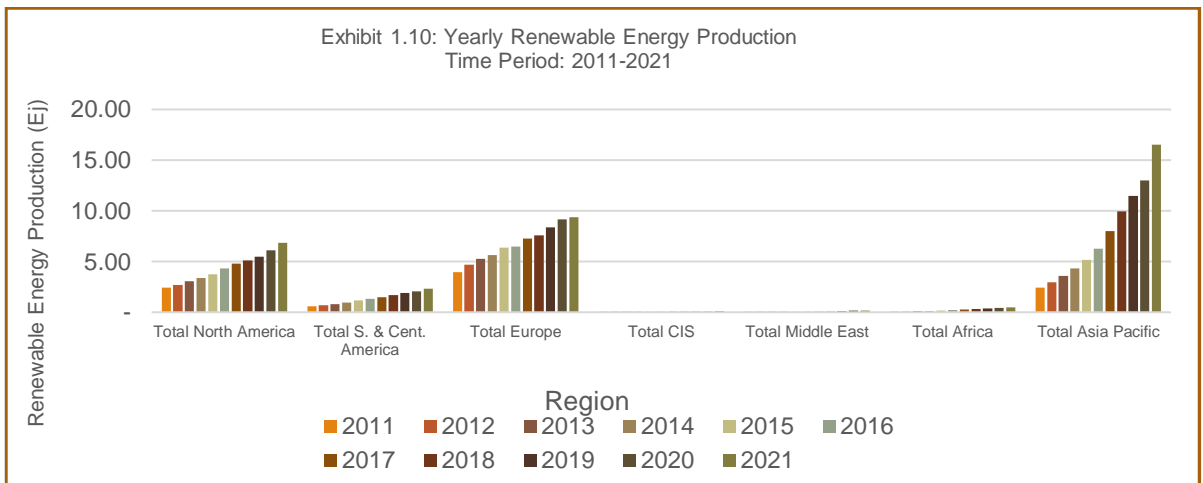
- India too have committed to achieve 40% of non-fossil fuel electricity by 2030.
- Few countries have exceptionally outperformed in adoption of renewable energy, China has achieved its 2020 target by 2017, and the European nations Sweden, Portugal, France have the most advanced progress with 77%, 66%, 65% respectively.
- Rising interest of the nations across the globe is now to increase the share of renewable energy in the energy mix and meet the rising demand of energy by overcoming the high energy costs:
  - ➔ Pronounced strategies and framework are designed at the global level to make renewable energy penetrated into the energy mix
  - ➔ Countries at the local level with marked responses are designing framework and policies to make integrate renewable energy in the production process (especially in electricity generation),



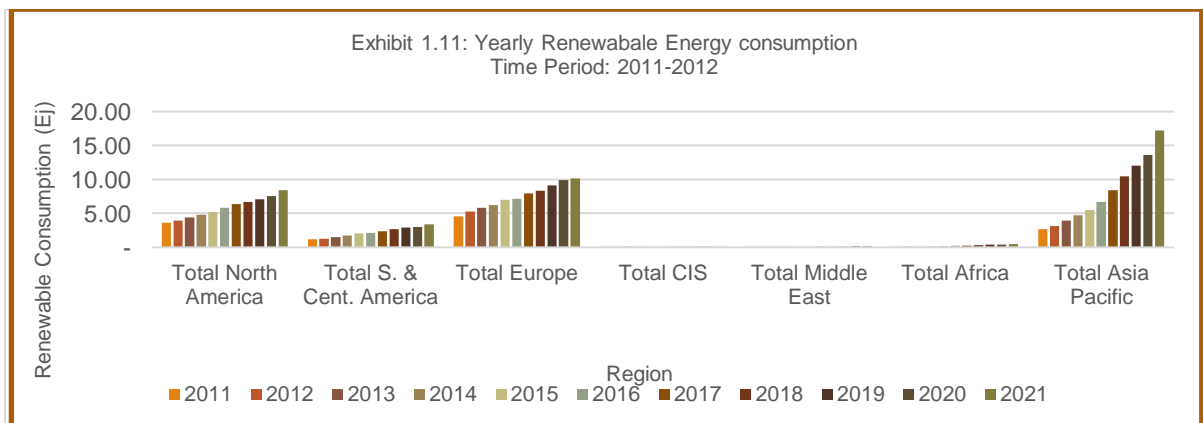
- ✓ such as 61 countries introducing a feed-in tariff (FIT)
- ✓ and the introduction of green certificates or auction systems with Europe leading implementation.



Source: LSI Research calculations based on data from BP-Statistics



Source: LSI Research calculations based on data from BP-Statistics



Source: LSI Research calculations based on data from BP-Statistics



In the period 2011-2021, World renewable energy production growth per annum has been 14.2% (BP-statistics) and renewable energy consumption growth per annum is 12.6% (BP-statistics). From exhibit 1.9, world-wide aggregative growth rate of consumption and production of renewable energy in every region is almost found to be equivalent, with a certain extra percentage of renewable energy production. But it can be deduced that adoptability of renewable energy in consumption side has been moderately good with proportion to the production. From exhibit 1.10 and 1.11 it is observed that over the time period 2011-2021 the production and consumption of renewable energy has an increasing trend in almost all the continents.

- Among all the region North America and Europe is having uniform increase in the production and consumption growth of the renewable energy. Many developed countries of the world being highly industrialised, have high percentage of carbon emission and USA being the second highest polluter of CO<sub>2</sub>. But North American countries also lead in renewable energy production, with the United States pioneering in all fronts with production of renewable energy of about 6.87 EJ as of 2021.
- In Europe, among various countries like Sweden, Finland, Portugal, Denmark, Germany, and France leads the renewable energy production in the continent. Sweden is considered for discussion as it is one of the pioneering countries which lead towards a low-carbon economy with nearly 60% of energy coming from RE sources. It has an installed capacity of about 29.06 GW, according to a report by IRENA (International Renewable Energy Agency). It is a part of IEA (International Energy Agency) since 1974, and currently, the country has the second-lowest CO<sub>2</sub> emissions in the world and which is about 1/4th of the United States of America. The country has already achieved 50% RE in total energy production way back in 2012, and now it is on track to achieve 100% RE production by 2040.
- Total renewable energy production of African countries stands as 0.47 EJ as of 2021. African countries like Ethiopia, Egypt, Morocco, South Africa leads the renewable energy production. South Africa is the pioneer regarding renewable energy production among the African countries, and the National Development Plan 2030 aims to make a decent investment in renewable energy capacity and generation. Middle eastern countries have started of lately the journey of renewable energy but has a significant amount of growth percentage in production and consumption of renewable energy.
- Among the Asian countries, China leads in renewable energy production followed by India and Japan. China, the world's most populous nation and is one of the largest renewable energy-producing nations achieving through its enormous potential in solar and installed capacity in hydroelectric and wind energy. As of 2021 China's production of renewable energy was 1152.5, which was six times greater than India's total production of renewable energy. India's energy policy on self-security for energy takes proactive steps in developing cutting-edge technology in improving the efficiency of plants and delivering quality renewable energy and expansion of its various facilities across the nation.



### **In Indian Context:**

India is taking noteworthy measurements by embracing renewable energy and increasing its share in the energy mix, to address the issue of curtailing carbon emission and ameliorating the environmental quality. Progressive and comprehensive steps to achieve the sustainable development growth path is visible in energy policies framed by India. Continuous target is set by the government regarding the adoptability of the renewable energy and reduce global warming year on year basis.

- ❖ By 2025 Indian government is targeting to scale down the production of traditional vehicles and adopting electric vehicles to overcome the dual challenge of reducing global warming and curb the import bill by cutting the energy imports.
- ❖ Consequence of shifting towards electric vehicle would be increasing electricity demand, and the ramification of supplying that particular demand by means of thermal sources would ultimately be bringing back India to square one. So, to avoid this unwelcomed outcome it is imperative to adopt renewable energy in electricity generation.
- ❖ The International Energy Agency (IEA) proposed that India will be the 2nd most significant contributor to global energy demand by 2035. From the results of load forecasting by IEA, it is clear that the demand of 90000 MW should be met to fulfil the basic electrical needs in 2035.

In India, historically at different stages of economic growth, carbon emission has been coupled with it, but now India has incorporated environment friendly growth strategies.

- ✓ Indian railway has set the target of net zero emission by 2030, which will curtail carbon emission by 60 million ton annually (according to MNRE).
- ✓ India also led a programme of UJALA LED Bulb, which reduced the carbon emission by 40 million ton annually (according to MNRE).
- ✓ The comprehensive approach towards green economy is extended by the launch of National Hydrogen Mission in 2013.

India is the world third largest producer of renewable energy, with 40% of its installed capacity in electricity coming from renewable energy fulfilling the target of 2030. India's target of achieving net zero emission is by 2070. And to reach this bigger goal India has set interim targets, which includes –:

- ❖ Increasing renewables capacity to 500 GW by 2030.
- ❖ Meeting 50% of energy requirements from renewables, reducing cumulative emissions by one billion tonnes by 2030.
- ❖ Reducing emissions intensity of India's gross domestic product (GDP) by 45% by 2030 i.e., 500 GW non-fossil energy, in line with PM's announcement in UN 26th Conference of Parties (COP 26) at Glasgow in November, 2021.

### **Installed Capacities of Renewable Energy sources in India as of 2022:**

Solar	Wind	Small hydro	Large hydro	Biopower	Nuclear
48.55 GW	40.03 GW	4.83 GW	46.51 GW	10.62 GW	6.78 GW

Source: MNRE

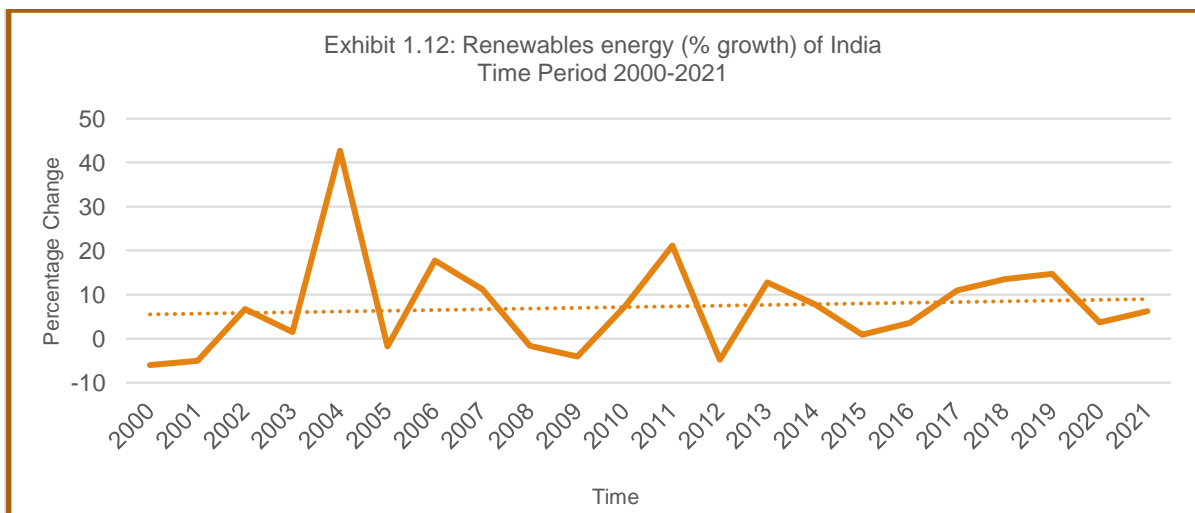


### **Transition towards Renewable Energy:**

Since independence, India had to heavily depend on coal to meet its power demand. Focussing on sustainable development India has strategically carried its mission towards alternative energy.

- Starting with hydroelectric power projects. India today stands at 5<sup>th</sup> in the world with respect to hydropower potential.
- India invested huge amount of labor and capital extensively in scientific research and technology development in nuclear energy segment. In 1950 Bhabha Atomic Research Centre (BARC) was established with the support of scientific community of India and has a major role in long term energy independence of the nation.
- In 1960 National Aeronautical Laboratory (NAL) developed wind mills, primarily for supplying irrigation water. India, with good constant supply of wind in Northern, Western and Southern part of India has progressed to become 4<sup>th</sup> largest in wind power in the world.
- Another essential source of renewable energy for India is biomass. It is carbon neutral and has the significant role in generating rural employment. Biomass co-firing in thermal power plant is taking place to reduce carbon footprints during thermal power generation. Over 800 biomass power and bagasse/non-bagasse cogeneration projects have been installed in India to supply power to the grid.

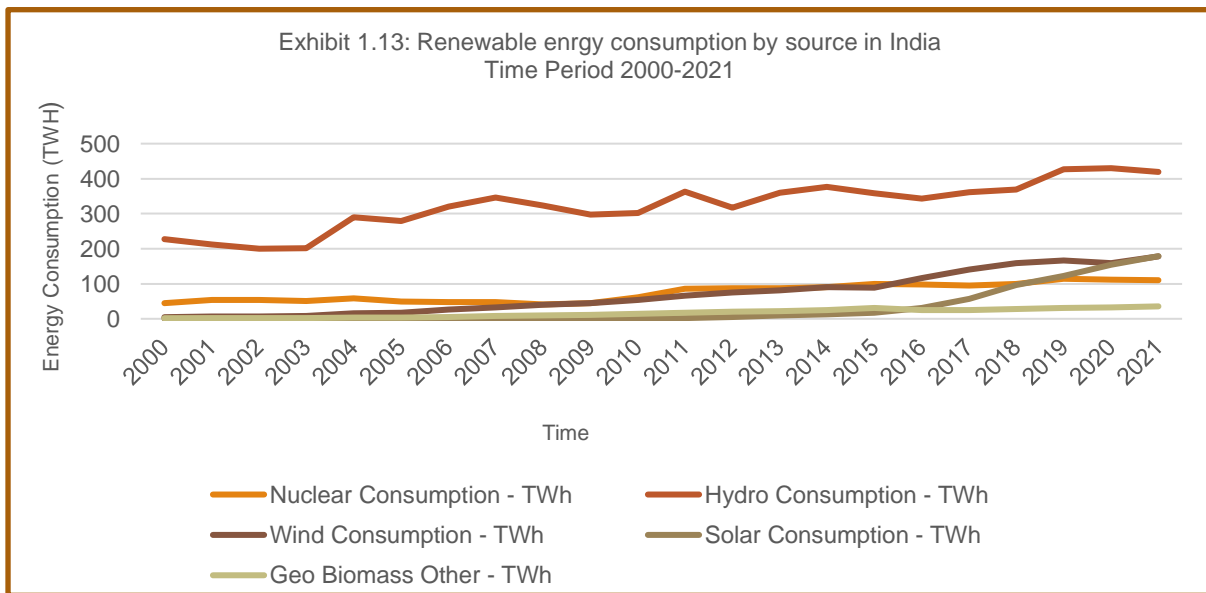
**Amongst all the renewable energy, the solar energy has the most potential in India**, and India has explored and invested by far the most in solar energy. People of India has been benefited using solar energy-based applications such as lighting, cooking and other energy needs in an environmentally friendly manner. *After progressing with satisfactory achievement in solar energy sector domestically, India has vanguard the International Solar Alliance (ISA)- a collaborative platform of member states of United Nation, for increased deployment of solar energy technologies.* At present ISA has 107 signatories and the soul objective of this framework to utilise more solar energy and reduce carbon emission.



*Source: LSI Research calculation based on data from BP-statistics*



- Empirically it is observed in exhibit 1.12 that growth in percentage change of renewable energy generation in India has been volatile over the time span of 2000-2021, but notably the growth has been increasing since 2016, after the Paris agreement in 2015. Though there was a steep fall in 2020 due to less energy demand during pandemic induced lock down, but the growth has been back to its usual course when the economic activities resumed. The trend in change of growth is also observe to be rising uniformly and to mention CAGR from 2011-21 has been 14.2%.



*Source: LSI Research calculation based on data from BP-statistics*

- Renewable energy consumption from all its sources has been depicted in exhibit 1.13, and it is found that consumption from hydro has been all time high being the traditional non-fossil fuel source of energy. Energy generation from wind has increased from 2006-07 and following a rising trend since then, and amongst all form consumption of solar energy has taken a steep rise since 2015 onwards and is having the highest increasing trend in consumption growth in recent times.



### **Achievements & Progress under various schemes of the MNRE as of 2021:**

1	Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) for decentralised solar	As on 31.12.2021, 25.25 MW capacity solar power plants were installed under scheme's Component-A, over 75,000 stand-alone solar pumps were installed under Component-B and over 1000 pumps were reported solarised under individual pump solarisation variant of Component-C
2	Roof Top Solar (RTS) Programme Phase-II	Over 5.87 GW capacity of grid connected RTS plants were installed, as on 31.12.2021, against the 40 GW target.
3	Central Public Sector Undertaking (CPSU) Scheme for Grid Connected Solar Photovoltaic (PV) Power Project	Under this scheme, around 8.2 GW of projects were sanctioned, as on 31.12.2021, against the 12 GW target.
4	Development of Solar Parks and Ultra Mega Solar Power Projects	Under this scheme, 50 solar parks with a cumulative capacity of 33.82 GW in 14 States were approved, as on 31.12.2021, against the March, 2022 target of 40 GW
5	Domestic manufacturing	Production Linked Incentive (PLI) Scheme, 'National Programme on High Efficiency Solar PV Modules', was approved in April, 2021 with an outlay of Rs. 4500 crores for scaling up indigenous fully integrated manufacturing units. Three successful bids for setting up 8737 MW manufacturing capacity were also awarded in 2021
6	Green Energy Corridor	As on 31.12.2021, works related to installation of transmission towers and their stringing for an aggregate approx. 8468 km have been completed, and substations of aggregate capacity of approx. 15268 MVA have been charged
7	Human Resource Development Programme	Under this programme, a total number of 50,537 Suryamitras were trained till December, 2021.
8	Renewable Energy Research and Technology Development (RE-RTD) Programme	Various R&D projects were continued with emphasis on cost reduction, reliability and efficiency improvement of renewable energy systems and components.
9	Green Hydrogen	The National Hydrogen Mission was announced by the Hon'ble Prime Minister in his Independence Day speech on 15th August, 2021. The Ministry is putting together a Green Hydrogen Roadmap to action this ambition and to turn India into a Global Green Hydrogen Hub.
10	Energy Storage	The storage tenders in India have evolved from RTC, peak power and now, standalone ESS. SECI issued tender for 1000 MWh Battery Energy Storage System (BESS) in October, 2021 to enable DISCOMS to use storage facilities on an on-demand basis
11	Carbon-Neutral Ladakh	A combination of solar park, hydrogen, and geothermal projects are being planned to fulfill the country's vision of a carbon neutral Ladakh. India's first geothermal pilot plant will be commissioned in Ladakh. A 20 MW solar power project integrated with 50 MWh Battery Energy Storage System was initiated in Phyang, located in the Leh district of Ladakh. The Union Territory of Ladakh announced the provision of 20,000 acres of land at Pang to set up 10 GW of renewable energy projects, in November, 2021.
12	Green Energy Corridor	The second phase of Intra-State Transmission System Green Energy Corridor Scheme was approved on January 6, 2022, under which transmission infrastructure would be set up in 7 States, namely, Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu, and Uttar Pradesh.

Source: MNRE Annual Report 2021

