

Sustainable Development is the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. But the scale, spread and pace of development have become boundless and consequently require extensive use of energy and resources. This has posed an inevitable challenge of balancing the spirit of human endeavour to conquer new heights without compromising the fundamental principles of sustainable development.

Energy Sector

- The progress and development targets achieved by the human civilization rest upon the wide and extensive use of energy in different forms.
- While discussing the sustainable alternatives it is largely accepted that choosing an energy strategy inevitably means choosing an environmental strategy.
- As on today India is consuming about 9000 billion units of energy for various purposes.
- About 47% of the total energy is sourced from coal and lignite, 31 per cent from crude oil, about 15 per cent from electricity (hydro, nuclear and other renewable sources) and 8 per cent from natural gas.

Impact of Fossil Fuels

- Other than the never-ending fear of extinction and carbon emission the fossil fuels also pose many strategic and health challenges.
- The changing climate is affecting the spread of infectious diseases, putting populations at higher risk of emerging diseases and co-epidemics and coastal waters are becoming more suitable for the transmission of vibrio pathogens (a major food-borne pathogen that causes life-threatening diseases in humans after the consumption of raw or undercooked seafood).
- These facts clearly indicate that the development achieved through burning of fossil fuels cannot be sustainable and that we must explore renewable energy options.
- India has updated the Nationally Determined Contributions which embody efforts by each country to reduce national emissions as stipulated in Paris Agreement.
- India now stands committed to reduce Emissions Intensity of its GDP by 45% by 2030 from 2005 level and achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

Renewable Energy

- Keeping in mind the sustainable development goals, India's power generation mix is rapidly shifting towards a more significant share of renewable energy.
- Today, India is the world's largest producer of renewable energy with about 42% of our installed electricity capacity coming from non-fossil fuel sources.
- Estimated renewable energy potential of India (other than large hydro) is about 1.5 million MW, of which 50% is from solar, 46.7% is from wind, and the remaining from small-hydro, biomass, and waste to energy.

Solar Power

- The last decade has witnessed surge in the use of solar energy based decentralized and distributed applications. Millions of Indians are now using solar power for lighting, cooking, mobility, and other energy needs.

- The solar power-based cooking has significantly improved quality of life, especially of rural women and girl children, by reducing the drudgery of long haul of fuel woods and risk of lung and ailments caused by kitchen smoke.
- Easy access to power in remote areas have boosted economic activities and employment opportunities, and thus helped in mainstreaming the under-developed zones.

Wind Power

- The Government has been promoting wind power projects by incentivizing the investments through Accelerated Depreciation Benefit, which allows an investor to claim higher rate of depreciation in wind power infrastructure than that for the general assets.
- The allowed rate of depreciation was 100% when the scheme was first introduced in 1994 and later rationalized to 80% and to 40% in a phased manner.
- In 2015, Government of India notified National Offshore Wind Energy Policy with the primary objective of exploring and promoting deployment of offshore wind farms in the Exclusive Economic Zone (EEZ) of the country, including those under Public Private Partnership.

Hydro Power

- According to the assessment made by Central Electricity Authority (CEA), India has the potential of economically exploitable hydropower to the tune of 1,48,700 MW.
- If the probable capacity of pumped storage of 94000 MW and that of about 6700 MW from small, mini and micro hydel projects are considered, India's hydro power potential will be about 2,50,000 MW.
- However, only less than 30 per cent of this is presently exploited despite having long life, low cost and high efficiency among many other advantages.

Biofuels

- Ethanol and biodiesel are the two most common types of biofuels in use today.
- Ethanol is a renewable fuel that can be made from various plant materials, collectively known as biomass.
- Government has been implementing Ethanol Blended Petrol (EBP) Programme wherein the Oil Marketing Companies (OMCs) sell petrol blended with 10 per cent ethanol.
- Biodiesel is a liquid fuel produced from renewable sources, such as new and used vegetable oils and animal fats and is a cleaner-burning replacement for petroleum-based diesel fuel.
- The National policy on Biofuels announced in 2018 is aimed at accelerated promotion of biofuels with indicative targets of achieving 20 percent blending in petrol and 5 percent blending in diesel by 2030.

Green Hydrogen

- The National Hydrogen Mission launched on India's 75th Independence Day aims to make India a green hydrogen hub which will help in meeting the target of production of 5 million tonnes of green hydrogen by 2030 and the related development of renewable energy capacity.
- National Thermal Power Corporation (NTPC) has commissioned India's first green hydrogen blending project in the piped natural gas (PNG) network of NTPC Kawas township, Surat, to supply H₂-NG (Hydrogen -Natural Gas) to the households in the township.

Ocean and Geothermal

- The technology development in these areas is at research and development stage.
- The estimated theoretical power potentials for Tidal and Wave energy are 12,455 MW and 41,300 MW respectively.

Renewable Powered Airport

- Cochin International Airport Limited (CIAL) has successfully turned their disadvantage of power deficit to an advantage to become the world's first solar powered airport.
- The CIAL ventured into the Solar PV sector in early 2013 by installing a 100 kWp solar PV Plant on the roof top of the arrival terminal block. Following this, one MWp solar PV power plant was installed partly on the roof top and partly on the ground in the aircraft maintenance hangar facility.
- As on today CIAL has an installed solar power capacity of 50 MWp.

Food Security and Renewables

- After land, water and energy are the two paramount resources in ensuring food security and thereby, catalyzing the human centric development.
- Ratio of volume of ground water extracted every year to the annual ground water recharge, referred as stage of groundwater development, in the country is 61.6 per cent.
- The stage of ground water extraction is very high in the states of Delhi, Haryana, Punjab and Rajasthan, where it is more than 100 per cent, which implies that in these states the annual ground water consumption is more than annual extractable ground water resources.
- The decline of ground water table leads to the consumption of more energy every year to meet the irrigation requirements. Use of renewables plays a major role in ensuring gains for the water– energy–food nexus.

Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan Yojana (PM-KUSUM)

- The objective of the scheme is to provide clean energy to more than 3.5 million farmers and to enhance their income by providing the option to sell the energy generated more than their pumping requirement to the power distribution companies (DISCOMs).
- The scheme has three components viz.,
 - Addition of 10,000 MW of solar capacity through installation of small solar power plants of capacity up to 2 MW.
 - Installation of 2.0 million standalone solar powered agricultural pumps.
 - Solarization of 1.5 million existing Grid–connected Agriculture Pumps.
- Scheme has helped in spreading awareness among farmers about advantages of using solar pumps.

Way Forward

Research and development must be augmented in the direction of generating more energy with less space. Moreover, there should be an international cooperation, synergy and harmony in tapping the renewable resources by way of exchange of technology, sharing the benefits of advancements in scientific research and space technology, in assessing the global risks and making informed choices.

Like other economic sectors, agriculture also demands high energy inputs in many of its activities, mainly irrigation. It consumes nearly 20% of the electricity consumed at national level. Renewable energy (RE) has emerged as the most viable and sustainable option to address the environmental concerns and meet the targets as envisaged by Government of India. It promises to increase income of farmers and saving of precious natural resources, mainly water. Ministry of New and Renewable Energy (MNRE) implements various schemes sponsored by Central Government and facilitates related research, design, development and manufacture of RE.

Resources At Work

Biogas

- Biogas is one of the most popular and versatile form of RE deployed extensively in rural India to serve many purposes.
- Biogas plants help with waste management, reduce energy costs, improve soil fertility, and curb carbon emissions.
- Proper waste management on farms leads to better cleanliness and hygiene which improves the living conditions and health of the community.
- The biogas sector has helped generate employment for both skilled and unskilled rural people.
- Government of India is promoting installation of biogas plants by providing subsidy through two major schemes:
 - New National Biogas and Organic Manure Programme (NNBOMP) for biogas plants in size range of 1 cu.m. to 25 cu.m. per day.
 - Biogas Power Generation (off-grid) and Thermal Energy Application Programme (BPGTP) for setting up biogas plants in the size range of 30 cu.m. to 2500 cu.m. per day.
- Biogas plants installed under BPGTP fulfil the electrical or thermal requirements of the dairy plants, poultry houses and dairy co-operatives.
- Power is used for milk chilling and other general applications such as pumping, lighting, irrigation, and cooking. The surplus biogas/power can be supplied to neighborhood dwelling units or farms in off-grid mode on payment basis.
- Government of India has launched a dedicated GOBARdhan (Galvanising Organic Bio-Agro Resources Dhan) scheme (Swachh Bharat Mission Grameen Phase-2) with twin objectives – to make the villages clean and generate clean power from organic wastes.
- Technical and financial assistance under the scheme is attracting entrepreneurs for establishing community based CBG plants in rural areas. CBG is a purified form of biogas (98 per cent purity of methane content) which makes it suitable for use as green and clean fuel for transportation or filling in cylinders at high pressure (250 bar).

Biomass

- Biomass is another potential source of RE in rural India that provides power for household needs and irrigation as well. Biomass materials used for power generation primarily include bagasse, rice husk, straw, crop waste and agricultural residues.

- Power from biomass is generated by installing biomass gasifiers in proximity to the source of raw materials to reduce costs.

Sun At Service

- Addressing the energy concerns in agriculture sector, a large number of solar devices/ equipments have been developed and deployed that include solar water pumps, solar dryers, solar dusters etc.
- But PM–KUSUM (Pradhan Mantri Kisan Urja Surkasha Evan Utthaan Mahaabhiyan) scheme launched in 2019, has emerged as a real game changer for energy security of farming community. It is one of the largest initiatives of the world to provide clean energy to more than 35 lakh farmers and also enhance their income. The scheme is being implemented through three objectives with following objectives:
 - **Component A: Decentralized Grid Connected Solar Power Plants (Target- 10,000 MW)**
 - This component intends to make farmer 'URJA DATA' by installing small solar power plant (up to 2 MW capacity) on his barren, fallow, pasture, or marshy land, and selling the generated power to electricity Distribution Companies (DISCOMS) on a pre–determined rate.
 - The solar plant will be a sustainable source of income for 25 years.
 - The Reserve Bank of India has notified this component under priority sector lending that allows competitive rates and soft terms.
 - The Central Government provides financial incentive to DISCOMS for purchase of power from such solar plants.
 - **Component B: Installation of Standalone Solar Powered Agriculture Pumps (Target- 20 lakh)**
 - Under this component, individual farmers can replace their existing diesel pumps with solar pumps through Central Financial Assistance (30 per cent of the benchmark cost) and State Government's subsidy (30 per cent).
 - The remaining 40 percent will be borne by the farmer, but bank finance for 30 per cent is available, so farmer will have to initially pay only 10 per cent of the cost.
 - Group of farmers, water use associations and community/ cluster–based irrigation systems are also eligible for financial assistance.
 - Solar pumps of capacity upto 7.5 HP are allowed in the scheme, however, if a farmer goes for higher capacity solar pump the financial assistance will be limited to 7.5 HP
 - **Component C: Solarisation of existing Grid connected agriculture pumps (Target- 15 Lakh)**
 - Exclusive power feeders for agricultural purposes will be solarised by installing solar power plants of required capacity.
 - This will lower the cost of capital and cost of power. The farmer will get daytime reliable power for irrigation free of cost or at a tariff as fixed by their respective states.
 - The scheme also has direct employment generation potential.
- Solar water pumps are the most popular ones with wide scale adoption across the country. Technically called Solar PV (Photo Voltaic) pumping systems, these are of great utility specifically in low head situations like water lifting from canals, shallow wells and dug wells, farm ponds etc.
- The solar sprayer is especially useful for safe and effective spray of pesticides for low height field and vegetable crops.

- Solar driers of various designs and types have been developed for a variety of agricultural produce including fruits, vegetables, and cereals. Solar preservators have also been developed for preserving and enhancing shelf life of fruits and vegetables.

Way Forward

Due to immense potential and scope of renewable energy in agriculture sector, Government is focusing on decentralised RE systems and products. MNRE has recently released a framework (2022) to promote RE based applications that are used for earning livelihoods. However, financing for the end-users and enterprises would be critical to enable the adoption of solutions and scale-up of the sector.

DECARBONIZATION OF TRANSPORT SECTOR

- Out of many sectors, including steel, railways, shipping, aviation, energy, road transport, etc., land transport is the one that can be shifted to zero tailpipe emissions mode.
- In the current context, electric vehicles (EVs) provide this solution and are already much greener than Internal Combustion Engine (ICE) based vehicles.
- India's transport demand is expected to increase by 2.7 times in over 30 years. EVs are as green as the electricity powering them and the sustainable supply chain of batteries.
- Mass mobility relies on public transport, two-wheelers, and three-wheelers. Therefore, FAME II was focused on these three segments.
- After the remodeled FAME II was launched in June 2021, the sales have increased by manifolds.
- In parallel, India witnessed the lowest price ever for 5450 electric buses tender (one of the biggest tenders in the world for e-buses). This paves the way for electrification of entire bus market in India (consolidated and fragmented).
- These buses are Zero tailpipe emission, minimal noise, clutch-free, and low maintenance (few moving parts compared to Internal Combustion Engine/ CNG buses).
- This will help save on CO₂ emissions, Fossil fuels, and lower noise pollution. The charging infra for city buses shall be located mainly at depots. However, for intercity transport solutions such as opportunity charging, and hybrid battery storage models (with fixed and swap battery) need to be explored.
- Electric two-wheelers will also see Mobility on Demand (MoD) and Mobility as a Service (MaaS) models to develop. This is because the upfront cost of fixed-battery electric two-wheelers is still higher than ICE vehicles (On a total cost of ownership basis, EVs are cheaper).
- In the case of electric two-wheelers engaged in commercial applications or requiring high run, operating models such as battery as a service (Baas) are evolving. The battery swapping provides the benefit of zero downtime, higher range, low price (As you only own the vehicle and the battery is on subscription), freedom from the risk of battery obsolescence, and higher safety (battery goes back to the OEM-powered charging dock after every use).
- Further, the dominant part of EV (40-50 per cent of EV cost), i.e., cell manufacturing, will get established through this 50 GWh ACC Program. Several states have also rolled out the incentives for battery manufacturing.
- India needs to have million-plus fast chargers to cater to the needs of EVs, mainly four-wheelers, cargo three-wheelers, Light commercial vehicles (LCVs), and Buses (Mainly intercity).

- The battery swap stations in rural areas will change the EV adoption and Battery storage landscape. It could improve the electricity supply and quality in far-flung areas. For instance, the battery swap station in rural areas can be powered by localised solar power (small setups). These swap stations can serve as micro power grids, which can power the villages/houses in the vicinity and supply the excess power to the grid.
- Another part of India's transition to clean mobility is recycling and refurbishing used batteries. India needs a comprehensive mission plan to deal with ACC recycling. This is also important as >95 per cent of the original critical minerals can be recovered from these ACC batteries and reused in cell manufacturing.
- NITI Aayog is working with IITs to nudge them to start EV-specific courses. More than 15 IITs have already started the courses at the PG level.
- At the school level, also (since the large EV market is for speeds <25km/hr, which can be driven without license), awareness about the benefits and other conditions of cleaner rides needs to be taught.
- Further, “Shoonya – Zero pollution Mobility” is a consumer and corporate-facing campaign hosted by NITI Aayog. The campaign aims to accelerate the transition of vehicles used for ride-hailing and deliveries into electric vehicles (EVs) by creating awareness and demand for zero-pollution rides and deliveries in Indian cities.

Way Forward

India has laid an ambitious outline and policies to direct the country towards a cleaner, greener, and more connected world. The industry is also reciprocating the same, but the speed needs to pick up on all sides, including manufacturing and consumer acceptance.

- Mitigating Environmental Issues
- As per World Energy Outlook 2021 of International Energy Agency (IEA), the current share of India in global primary energy consumption is 6.1 percent. Over 80 percent of India's energy needs are met by three fuels: coal, oil, and solid biomass.
- In the energy sectors (both for developing and developed countries) widespread use of renewable energy is important for achieving sustainability.
- In 2008, National Action Plan on Climate Change (NAPCC) was prepared which has eight missions as a multi-pronged, long-term, and integrated approach to address climate change. It has overarching policy framework for all climate actions including the expansion of solar energy resources.
- Long-Term Low-Carbon Development Strategy submitted by India under United Nations Framework Convention on Climate Change (UNFCCC) focus on rational utilisation of natural resources with the due regard to energy security.
- The Climate Change Action Plan (CCAP) launched during the 12th Five Year Plan with an outlay of Rs. 290 Cr. to build capacity and support implementation of relevant climate change related actions at the national and State level.
- Another scheme, the National Adaptation Fund for Climate Change (NAFCC), established in August 2015, with the aim of meeting the cost of climate change adaptation for states and union territories in India which are vulnerable to the impacts of climate change.
- India at the 26th session of the Conference of the Parties (COP 26) to the UNFCCC held in Glasgow, presented 'Panchamrit' of India's climate action. These were:
 - India will get its non-fossil energy capacity to 500 gigawatts (GW) by 2030

- India will meet 50 per cent of its energy requirements from renewable energy by 2030
- India will reduce the total projected carbon emissions by one billion tonnes from now onwards till 2030.
- By 2030, India will reduce the carbon intensity of its economy by less than 45 per cent.
- By the year 2070, India will achieve the target of Net Zero.
- The Production-Linked Incentive (PLI) Scheme in High Efficiency Solar PV Modules for Enhancing India's Manufacturing Capabilities and Enhancing Exports – AatmaNirbhar Bharat with the scheme outlay as Rs. 24,000 cr, (www.investindia.gov.in) aims to reduce import dependence in energy sector. The PLI scheme has six objectives which are as follows:
 - To build up solar PV manufacturing capacity of high efficiency modules.
 - To bring cutting-edge technology to India for manufacturing high efficiency modules. Technologies which yield better module performance will be incentivised.
 - To promote setting up of integrated plants for better quality control and competitiveness.
 - To develop ecosystem for sourcing of local material in solar manufacturing.
 - Employment generation and technological self-sufficiency.
 - To encourage sustainable manufacturing practices and adoption of circular economy approaches.
- Green Energy Corridors is another programme implemented by MNRE in the country to promote renewable energy sources, to create intra-state transmission system for renewable energy projects.
- Central financial assistance is provided to set up transmission infrastructure for evacuation of Power from Renewable Energy projects.
- Modhera, a village in the Mehsana district of Gujarat was declared India's first solar-powered village.
- Conversion to a clean, renewable energy source is not only enabling the villagers to run more electrical household gadgets to make life comfortable, without worrying about the electricity bill but also becoming a source of income for them (UN News).

Way Forward

- Renewable energy technologies need to be strengthened by education and training programs (knowledge awareness).
- Energy Conservation (Amendment) Bill, 2022 which focus on the use of non-fossil energy (biomass, ethanol, green hydrogen) to decarbonise Indian economy, will also allow carbon credit trading.
- These initiatives will help India achieve targets of Paris Climate Agreement and significantly contributes towards reducing the pollution load and thereby mitigating environmental problems.
- It will also have bearing on the targets set in Global Biodiversity Framework under the COP-15 of Convention on Biological Diversity to protect the world's biodiversity.

PUBLIC AWARENESS ABOUT RENEWABLE ENERGY SOURCES

The shift towards renewable energy has the potential to make countries self-sufficient in terms of energy security. Considering its possibility to decarbonise the energy system and ensure self-sufficiency, recent years have seen a

rise in interest in clean energy as various economies and nations seek to reduce their reliance on highly polluting fossil fuels.

Renewable Energy: Concept and Implications

- Renewable energy sources are expected to account for over 90 per cent of global electricity expansion over the next five years, surpassing coal to become the largest source of global electricity by early 2025.
- The Economic Survey 2021–22 reports that renewable energy contributes to approximately 10.7 per cent of India's power generation, followed by coal.
- The transition from conventional to green energy has experienced the fastest rate of growth among all large economies, with renewable energy capacity increasing by 2.9 times and solar energy expanding by over 18 times.

Public Awareness Related to Renewable Energy: Concept, Implications and Determinants

- In the context of renewable energy, public awareness refers to the level of understanding and knowledge that members of a society have about renewable energy sources and technologies. It can be seen as a measure of how well-informed the public is about renewable energy and can be influenced by various factors such as media coverage, public education campaigns, and personal experiences.
- Public awareness can help in promoting the involvement of citizens in the decision-making processes that shape energy policies.
- By raising awareness about renewable energy options, individuals can be motivated to engage in activities such as supporting policy measures that promote the deployment of renewable energy, investing in renewable energy technologies, and advocating for change, which can help to bring about positive changes in energy policies and practices.
- Increasing public awareness of the adverse environmental impacts of fossil fuel use and of the potential provided by renewable energy sources will contribute to the realisation and expansion of renewable energy investments.
- The population's knowledge and opportunities related to renewable energy sources and their willingness to adopt them, depend on several factors: cost-effectiveness is one of the most important motivating factors, and social acceptance can be achieved by the returns following a positive cost-benefit calculation.
- Studies found six basic factors affecting the adoption of renewable energy, these are gender, age, education of the head of the household and education in general, occupation and interest in the environment, in technology, or in engineering; and consciousness about environmental behavior of people.
- Public understanding can be accomplished through a variety of approaches, such as education and outreach campaigns, financial incentives, and rules requiring the usage of renewable energy. For instance, Norway, which uses 92 per cent of its power from renewable power sources, has implemented several policy initiatives to promote renewable energy consumption.

Awareness Related to Renewable Energy: Role of Institution

- By raising public awareness, government decision-makers may be more likely to give renewable energy top priority, resulting in more laws and regulations that encourage the development of the renewable energy sector.
- Increasing public knowledge of renewable energy can accelerate the transition to a cleaner, more sustainable energy system when taken as a whole.

- The deployment of sustainable energy sources is crucial to a healthy relationship between society and the environment. Renewable energy is providing clean and cheap options for people that live in a friendly and healthy environment.
- To reach long-term policy targets related to renewable energy, the long-term continuity of policy support is crucial, along with financial, legal, administrative, technological, and cognitive frameworks.
- Along with financial and institutional support, finding a compromise and balance between private and public interests is argued to be one of the cornerstones of sustainable development.

Renewable Energy Promotion: The Indian Context

- To promote the use of renewable energy sources, an exclusive institution, the Department of Non-Conventional Energy Sources (DNES), was created in the Ministry of Energy in the year 1982. It was upgraded into a separate Ministry of Non-Conventional Energy Sources (MNES) in 1992 and was re-named as Ministry of New and Renewable Energy (MNRE) in October 2006. The Ministry is being supported by five institutes, namely,
 - National Institute of Solar Energy (NISE)
 - National Institute of Wind Energy (NIWE)
 - Sardar Swarn Singh National Institute of Bio Energy (SSS-NIBE)
 - Indian Renewable Energy Development Agency (IREDA)
 - Solar Energy Corporation of India (SECI).
- IREDA, a Non-Banking Financial Institution under the administrative control of this Ministry, provides term loans for renewable energy and energy efficiency projects.
- To enhance efficiency and responsiveness to people and to make people aware, the Ministry has brought out a Citizens'/Clients' Charter (CCC), incorporating its mission, main services/transactions and commitment to its clients and the people of India in general. It also aims at addressing problems of the interface between the Ministry and its Clients/ Citizens and continuously improving the quality of public services for the people at large to make them responsive to their needs and wishes.

Special Schemes

- National Solar Mission is one of the most important schemes of Government of India, being implemented by the Ministry of New and Renewable Energy. It aims to increase the share of solar energy in the total energy mix.
- The Pradhan Mantri Kishan Urja Suraksha evam Utthan Mahabhiyaan (PM-KUSUM) is another important scheme in this regard. It aims to add solar capacity of 30,800 MW by 2022.
- The National Mission on Strategic Knowledge for Climate Change is another initiative to make people aware. It seeks to build a knowledge system that would inform and support national action for ecologically sustainable development.

Conclusion

To be able to mitigate the negative impact of climate change and adopt renewable energy sources, individuals, households, communities, organisations, government, and other stakeholders must be engaged at relevant scales. This can be accomplished through a variety of approaches, such as education and outreach campaigns, financial incentives, and rules requiring the usage of renewable energy.

The ever-increasing need for energy for both human and economic growth has coincided with an increase in the variety of sources that may be used to generate energy. The generation and use of these energy resources are the primary contributors to the release of greenhouse gases all around the planet. Since, emissions of greenhouse gases are one of the primary causes of climate change, nations all over the globe are making concerted efforts to transition to cleaner forms of energy by altering the processes by which energy is generated.

Clean Energy

- The use of renewable energy sources is preferable for the health of the environment, regardless of whether we have an infinite supply of fossil fuels.
- The combustion of fossil fuels releases greenhouse gases into the atmosphere, which trap the sun's heat and contribute to global warming.
- Climate experts are nearly unanimous in their conclusion that the earth's average temperature has increased over the last century.
- If this pattern continues, there will be an increase in sea levels, and experts estimate that there will be an increase in the frequency of floods, heat waves, droughts, and other types of extreme weather events.

Energy Scenario

- In the recent past, India's energy sectors have embraced two new major developments-
 - First achievement- India has been successful in recent years in connecting hundreds of millions of its residents to the nation's electrical grid, which has contributed to an increase in the material well-being of a very large number of people.
 - Secondly, it has recognized the game changing potential of renewable energy and solar.
- As a result of steadily increasing earnings and generally better living conditions, India has risen to the position of the world's third-largest consumer of energy.
- Coal, oil, and biomass are the primary sources that contribute to India's ability to meet its energy demands.
- The increase in automobile ownership as well as road travel has increased oil consumption across the country.
- Urbanization and rising affluence have also led to an increased usage of residential appliances, driving up electricity consumption and outpacing total energy demand. The industry's usage of electric motors and other machines has further increased power demand.

Future of The Energy Sector

- Solar power, along with other forms of generation technology and energy storage, is encouraged to be combined to provide a "round-the-clock" supply, which is one of the driving forces behind the growth of renewable energy projects on a utility scale.
- In some Indian states with an abundance of renewable resources, such as solar and wind, the two resources together account for up to 15 per cent of the total electricity generation. But congestion on the grid, concerns regarding the development of grid infrastructure, and the weak financial status of many state distribution businesses are some of the challenges that need to be addressed and overcome.
- The rise of residential rooftop solar has lagged behind utility-scale installations due to higher pricing and a scarcity of financing options that are favourable to consumers.

- Because of the widespread use of home appliances, the proportion of total energy consumption that is met by electricity is expected to increase from the current 20 per cent to approximately 50 per cent by the year 2040.
- Electrification of India's energy infrastructure is a major factor in rising demand; power is being used more often in industries that benefit from a steady supply of low-temperature heat, and steel production is more dependent on electricity. Both trends are driven by significant increases in the consumption of electricity.
- Solar photovoltaic (PV) projects are now the most cost-effective technique for generating new power in India, and they are also among the most cost-effective methods worldwide. This is because solar energy has a lower cost per watt than other forms of renewable energy

Hydro Power

- In 2019, India achieved 50 gigawatts of potential hydropower capacity. However, hydropower's contribution to the overall mix of sources used to generate electricity has been steadily declining over the last few decades and now accounts for just around 10 per cent of total output.
- Sustainable Development Goals
- Several Sustainable Development Goals (SDGs) depend on air quality improvements to be achieved.
- Increasing household access to clean energy would reduce household pollution.
- Increasing energy efficiency would reduce air pollutant concentrations throughout the energy economy and expanding access to environmentally friendly transportation would improve the quality of the air in cities as a whole.
- Reduced greenhouse gas emissions are a direct side benefit of air pollution control policies.

Investment In Energy Sector

- Between 2019 and 2040, India will have the highest rise in energy demand of any country, accounting for about one-quarter of the total global increase.
- India, which is currently a major player in photovoltaic (PV), will take on a similar role in battery storage, attracting more than a third of global investment between 2019 and 2040.
- India's power system will grow larger than the European Union's by 2040. Furthermore, India's installed renewable energy capacity will be thirty per cent greater than that of the United States.
- India's policymakers will have the critical responsibility of managing the risks and geopolitical hazards connected with these increasingly crucial value chains.
- India will soon become one of the world's largest marketplaces for a range of renewable energy technologies, making it an important target for technology businesses that are looking to grow.
- Local production of solar photovoltaic (PV) cell would be able to satisfy a greater share of demand, which would be in line with the policy aim of the government to increase domestic manufacturing.
- The Advanced Chemistry Cell and Battery Gigafactory plan developed by NITI Aayog offers financial incentives to companies who want to construct battery cell plants.
- In addition, the first plant in India to produce anodes for lithium-ion batteries was recently commissioned in the state of Karnataka.

Future Is Green Energy

To make the necessary technological changes for energy transitions, India should examine current best practices for prioritizing technologies and encouraging public and private innovation in the relevant fields. New connections between industry and academic institutions may improve information exchange. Having access to enough funding is also crucial, and there must be an exploration into how international financial institutions might aid in the development of pre-commercial energy technologies.

RENEWABLE ENERGY TRANSFORMING RURAL WOMEN

Renewable Energy is transforming lives of women in rural areas in India and has potential to do more. It can drive energy availability in previously unconnected areas, generate jobs, enable social transformation, and accelerate economic growth.

Renewable Energy and Employment

- The National Institute of Solar Energy (NISE), an autonomous institute of MNRE, has organised the 'Surya Mitra' skill development program in collaboration with State Nodal Agencies. It will prepare candidates to become entrepreneurs in the solar energy sector. Special emphasis is being given to rural women candidates during the selection process.
- Memorandum of Understanding (MoU) signed between Smart Power India and the Central Electricity Supply Utility (CESU) of Odisha to improve power facilities in the state, not only set an example by employing skilled rural women but also generated evidence on the business benefit rural women employees bring.
- They leveraged the presence of Self-Help Groups (SHG) in each village and introduced the concept of 'Bijulee Didi'.

Renewable Energy as a boon to Rural Enterprise

- Workflow interruptions and the damage caused to sensitive electrical equipment by power fluctuations not only limit productivity but also hinder the establishment of new enterprises.
- Energy supply to rural households improves the efficiency of businesses and helps increase women's non-farm self-employment.
- Reliable energy access also affords women extra time that they can utilize in skill training sessions to get a job or start their own business.
- A women-led initiative, Hariyali Green, implemented by the Association of Renewable Energy Agencies of States (AREAS) under MNRE (AREAS-MNRE) along with the Natural Resources Defense Council (NRDC) and the Self-Employed Women's Association (SEWA) aimed to enhance access to clean energy technologies and improve livelihood opportunities at the household level in rural India.

Distributed Renewable Energy (DRE) Spurring Rural Women's Micro Entrepreneurship

- DRE is a renewable energy-based system that can generate and distribute energy independent of a centralised electricity grid and provides a wide range of services like lighting, cooking, space heating, and cooling.
- In February 2022, MNRE released a draft policy framework for promoting DRE livelihood applications with an explicit gender emphasis. It supports the adoption of DRE livelihood technologies among women by providing access to finance for entrepreneurs and end users.

- Established in 2013, Maitree Mahila, a dairy and agriculture producer company, is managed and run by rural women in Rajasthan's Dooni village.
- Another initiative by IIT Bombay, with major funding provided by MNRE, was Solar Urja through Localisation for Sustainability (SoULS). It aimed to provide clean, efficient, affordable, and reliable electricity even to the last mile households.

Clean Energy Technology Reduce Women's Drudgery

- Access to energy can benefit women both at macro and micro levels. At the macro level, it strengthens livelihoods and boosts local economies, while at the micro level, it is responsible and caters to 'time poverty'.
- The onset of new RE-powered efficient technologies, such as solar-powered spinning, reeling, and weaving machines, can help ease the lives of an estimated 45 million people directly employed by the Indian textile industry, 60 per cent of whom are women.
- Kuni Dehury, a resident of Kardapal village in Odisha's Keonjhar district, runs a silk spinning centre. The major factor that makes the centre unique is the application of solar power to run it. The centre uses Reshamsutra's solar-powered reeling machines because of which women do not have to bear the burden of electricity bills or the labour-intensive thigh reeling process. Reshamsutra is a PL-supported enterprise to upscale solar reeling machines and help rural women silk-reelers.
- The Ministry of Micro, Small and Medium Enterprises (MSME), through Mission Solar Charkha, aims to create 50 solar charkha clusters, which employs spinners, weavers, stitchers, and other skilled artisans.

Solar Pumps Powering Rural Women Farmers

- The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana (PM-KUSUM) scheme by the MNRE offers subsidies and other incentives like feed-in-tariffs to support the adoption of solar-powered irrigation systems.
- The Jharkhand Opportunities for Harnessing Rural Growth (JOHAR) project run by the Jharkhand State Livelihood Promotion Society (JSLPS) in collaboration with the World Bank supports tribal women SHG farmers in cultivating high-value crops by providing a 5–7.5 horsepower (HP) solar pump at a subsidized rate.

Resilient Rural Health Systems for Women

- Lack of reliable electricity in healthcare centres is associated with a decrease of 64 per cent in child deliveries affecting women's access to safe healthcare.
- Renewable energy can empower rural hospitals by providing uninterrupted electricity and upgrading basic and critical-care services.
- Social enterprises have developed portable maternity kits, which comprise portable solar torches and basic diagnostic kits for testing for anemia, blood sugar levels, and malaria in Kalahandi, Odisha.
- With the support of the solar kit, pregnant women were able to access check-ups at home, which has had a positive impact on mortality rates.

Solar Street Lights Boost Rural Women's Safety and Mobility

- Enabling streetlights provides more safety as darker areas face many crimes.
- Women restrict their activities and movements when they don't feel safe going outside, reducing personal empowerment and participation in the workforce.
- Solar streetlights have helped young girls to go for their tuition classes in the evening without fear.

Access to Clean Energy Equals Access to Better Education and Health

- Women, because of gender-based division in household work, are involved in collecting fuel for cooking and transporting them over long distances. This, in turn, reduces their time for study, schooling, or paid employment. Further, biomass fuel causes severe and long-term health problems such as respiratory diseases. This labour work along with creating time poverty for women also impacts their postures and leads to back pain.
- Providing clean energy access can reduce the drudgery among rural women, giving them time for education or skill upgradation and improving their health.

How Renewable Energy can help Rural Women

- Access to modern forms of energy is considered indispensable for alleviating poverty, accessing jobs, assuring independence, and providing social services.
- Long-term access to a reliable energy supply through DRE solutions builds services, self-resilience, and adaptive capacity among women.
- It decreases their vulnerability to climate change risks without requiring huge upfront infrastructure investment.
- This can be achieved by focusing on-
 - Need to educate and empower rural women on the benefits of RE and clean energy in improving their quality of life.
 - Empowering women as energy entrepreneurs with the support of the country's Entrepreneurship Development Programmes (EDPs).
 - Going beyond energy provision and focusing on the productive use of DRE to improve women's socio-economic participation.
 - "Engendering" energy programmes and policies by conducting gender sensitisation and capacity-building sessions with policymakers.
 - Targeted gender budgeting will assist and create a roadmap for each ministry and identify schemes and, therefore, implement process gaps.
 - A mechanism to collect sex-disaggregated data on policies/scheme end users across ministries needs to be developed to assist in better understanding the existing policy's impact on rural women and girls.

Only when women are at the centre of renewable energy expansion, will India be able to achieve both inclusive and sustainable growth.

INDIA: A GREEN HYDROGEN GLOBAL HUB

The National Green Hydrogen Mission seeks to promote development of green hydrogen production capacity. The Ministry of New and Renewable Energy (MNRE) will formulate the scheme guidelines for implementation. It will help India export high-value green products making it one of the first major economies to industrialize without the need to 'carbonize'.

Salient Features of The Mission

- Creation of export opportunities for green hydrogen and its derivatives.

- Decarbonisation of industrial, mobility and energy sectors.
- Reduction in dependence on imported fossil fuels and feedstock.
- Development of indigenous manufacturing capabilities.
- Creation of employment opportunities; and development of cutting-edge technologies.
- Facilitate demand creation, production, utilisation and export of green hydrogen.
- Under the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT), two distinct financial incentive mechanisms targeting domestic manufacturing of electrolyzers and production of green hydrogen will be provided under the Mission.
- Support pilot projects in emerging end-use sectors and production pathways.
- Regions capable of supporting large scale production and/or utilisation of hydrogen will be identified and developed as Green Hydrogen Hubs.
- Public-private partnership framework for R&D (Strategic Hydrogen Innovation Partnership – SHIP) will be facilitated under the Mission.
- R&D projects will be goal-oriented, time bound, and suitably scaled up to develop globally competitive technologies. A coordinated skill development programme will also be undertaken.
- All concerned ministries, departments, agencies and institutions of the central and state governments will undertake focussed and coordinated steps to ensure successful achievement of the Mission objectives.
- The manufacturers of Green Hydrogen / Ammonia and the renewable energy plant shall be given connectivity to the grid on priority basis to avoid any procedural delays.
- To ensure ease of doing business a single portal for carrying out all the activities including statutory clearances in a time bound manner will be set up by MNRE.

The Story So far

- In 2020, India's hydrogen demand stood at 6 million tonnes (MT) per year and is estimated that by 2030, the hydrogen costs will be down by 50 per cent. The demand for hydrogen is expected to see a five-fold jump to 28 MT by 2050 where 80 per cent of the demand is expected to be green in nature.
- Top industry leaders such as Reliance Industries Limited (RIL), Gas Authority of India Limited (GAIL), National Thermal Power Corporation (NTPC), Indian Oil Corporation (IOC) and Larsen and Toubro (L&T) plan to foray into the green hydrogen space.
- Pursuing Green Hydrogen aggressively, India has a distinct advantage in low-cost renewable-energy generation and world-class clean-power execution capabilities makes green hydrogen the most competitive form of hydrogen in the medium run. This enables India to be potentially one of the most competitive producers of green hydrogen in the world.
- Since 75 per cent of the cost of green hydrogen is dependent on renewable energy, India should target to further bring down the cost of solar power to Rs. 1 per Kw/h through lower cost of financing.
- Energy security is another reason to pursue green hydrogen as it will enable the emergence of a domestically produced energy carrier that can reduce the dependence on fossil fuel imports of \$ 160 bn per year.
- With proper policy support, industry action, market generation and increased investor interest, India can position itself as a low-cost, zero-carbon green hydrogen manufacturing hub of the world.

- Many sectors such as iron ore and steel, fertilisers, refining, methanol and maritime shipping emit major amounts of CO₂, and carbon free hydrogen will play a critical role in enabling deep decarbonisation.
- There is a need to consider developing new infrastructure rather than dismantling existing framework.
- Producing hydrogen requires diversion of excess renewable capacity since most of the energy produced is used up in meeting the constant energy demands. Hence, there is a need to produce more surplus energy.

Private Sector and Green Hydrogen Initiatives

- The future of hydrogen in India can also be seen from the interest in hydrogen by companies like Reliance Industries, Tata Group, Adani Group, Jindal, and more importantly, Indian Oil and NTPC.
- Pilot projects in hydrogen production, distribution, storage, and application have been already announced by these companies, and they are making massive investments in this sector to ensure they continue to have an edge in the energy sector.
- The investor interest is so high that western companies are also entering into India's green hydrogen market through joint ventures.
- India's Greenko is building a 2GW factory in partnership with Belgium's John Cockerill and Nevada-based Ohmium.
- Reliance is building electrolyser factories in partnership with Denmark's Stiesdal, and L&T with Norway's Hydrogen Pro.
- Gautam Adani has committed financing to a one GW factory as the first step in its recently announced plan to produce three million tonnes of hydrogen by 2030, which would require 16GW of electrolyser capacity.
- Adani Petrochemicals plans to offer a variety of green fuels and utilize its supply chains and RE units for production and transport. The company has a four-pronged plan to manufacture Green Hydrogen, Green Methanol, Green Ammonia and Green Fertilizer.
- Gurugram-based ACME Group has said it is planning to invest about Rs 1.5 trillion in green hydrogen and ammonia for its upcoming units in Tamil Nadu, Karnataka, and Oman.
- The RE company is also looking for foreign equity partners and off-take tie-ups for these projects.

Way Forward

India has set a target of an annual production capacity of 25 million tonnes by 2047. The number could well be revised upwards as the technology evolves and the demand outlook improves. Its current output of green hydrogen is low and comes from a just handful of pilot projects. It is in the process of finalizing a roadmap for becoming green hydrogen economy which would require Rs. 15 trillion and another Rs. 15 trillion to meet middle-term goal by 2030. So, in all, these initiatives would require an investment of Rs. 30 trillion by 2030.