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Green Energy Conversion

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Introduction

India has currently a population of 1.2 billion and is expected to grow to 1.69 billion[1]. This will make it the most populous country on earth. A large section of this population is facing frequent power cuts across the country due to the increased demand and decreased supply.[2] Simultaneously according to the data shared by the Central Electricity Authority (CEA), there are a total of 173 power plants in India of which 85 plants fired by domestic coal have less than 25% stock, and 11 plants running on imported coal have hit critical levels.[3] Due to the sudden increase in electricity and crude oil demand after the pandemic when economic activities increased, the prices have also gone high. The high prices of energy posses the risk of growth and increasing inflation.[4] So government should embrace the path of innovation in the area of green energy to maintain sustained economic growth. For sustained economic growth, every nation should consider free fuel-based energy conversion, environmental concerns, and conservation of water. This is very important for India because of its large population so an uninterrupted energy supply is ensured. Free fuel-based solar and wind energy sources can provide sustained economic growth. Lack of understanding regarding the role of photovoltaics (PV) as a major current and future energy technology in India is a major fundamental roadblock in the large-scale implementation of photovoltaics. Solar electricity can be generated at a very low cost if proper funding and incentives are provided to the companies. In addition to novel implementation and promotion of PV culture, there is an immediate need for action toward water-lifting for irrigation and drinking, and appropriate research directions in solid-state energy conversion and storage devices.

Renewable conversion

Over a century later, approximately 80% of global energy consumption still comes from burning fossil fuels.[5] Over that period modern renewables only grew from 8.7% to 11.2%. As the impact of climate change on the environment becomes increasingly drastic, there is a mounting sense of urgency for researchers and engineers to develop scalable renewable energy solutions. Instead of combusting fossil fuels to get power, we must use green energy type that is generated from natural resources such as sunlight, wind, or water. The with these energy resources is that they don't harm the environment such as releasing greenhouse gases into the atmosphere.

This issue is mostly related to environmental problems, yet the global conferences are dedicated to finding safe ways to convert all available energy to safe methods.

[1] UN projects India's population to be 1.69 billion by 2050.
[2] https://www.businessinsider.in/india/news/why-are-there-power-cuts-and-heatwave-in-india/articleshow/91177785.cms
[3] https://npp.gov.in/dailyCoalReports
[4] Elevated prices of energy and other commodities and supply-side disruptions due to the Russia-Ukraine conflict pose a challenge to the growth trajectory and upside risks to inflation, the Finance Ministry said in its monthly economic review report for March 2022.
[5] The group's Renewables 2021 Global Status Report says that fossil fuels accounted for 80.3% of energy consumption in 2009, compared with 80.2% in 2019.

The difference between the Renewable and Green energy

It is called green energy, a resource that cannot pollute the environment at any cost. This means that not all sources used by the renewable energy industry are green. For example, power generation that burns organic material from sustainable forests may be renewable, but it is not necessarily green because it produces CO2 through the burning process itself. Green energy sources can replenish naturally unlike fossil fuels that often take millions of years to develop. Green Sources are also obtained naturally not by mining or drilling which can be damaging to ecosystems.

The latest innovation and renewable trends

The need for a rapid transition to clean energy is enabling new developments in the renewable sector. Businesses and industries are moving towards renewable energy to reduce emissions, lower energy costs, and improve eco-friendliness. The major renewable energy trends include digitization, energy-efficient integrations, and solutions that overcome the intermittency in renewable energy production. For these reasons, the use of big data, artificial intelligence (AI), and the internet of energy (IoE) are emerging as popular trends in addition to innovations in renewable energy sources. Although renewable energies such as solar, wind, and hydroelectricity have been around for a long time, recent innovations make these some of the most trending technologies. Moreover, they dominate the industry due to their competitive advantages. Relatively newer areas of research in the renewable sector include energy from green hydrogen and water energy forms such as tidal, wave, and ocean currents.

1. Advanced Photovoltaics

Solar companies are modifying PV systems with every aspect of our surroundings while minimizing the need for additional land usage. Startups are developing thin-film cells to make solar panels flexible, cost-effective, lightweight, and environment-friendly. Companies are developing technologies to concentrate solar power using mirrors and lenses to improve the performance of PV. Innovations in PV materials, such as the use of perovskite, are increasing energy conversion multifold.[6] These innovations are further coupled with photovoltaic designs that enable maximum efficiency and high productivity. Nowadays the use of low carbon monocrystalline silicon ingots for high performance of photovoltaic devices promotes sustainability through recycling, minimum resource utilization, and the use of alternate materials.[7]

2. Distributed Energy Storage System

To overcome the problem of irregularities in production, DESS has taken major steps toward energy generation and storage.[8] At a time when people are facing regular power cuts, this type of power storage system can solve all the problems and can ensure a seamless power supply. Based on economic and other requirements, startups offer a range of battery and battery-less solutions.[9] For Instance, flow batteries leverage low and consistent energy, whereas solid-state batteries are lightweight and provide high energy density.[10] For applications that require large amounts of energy, in a short period, capacitors and supercapacitors are also used. Startups are devising battery-less storage alternatives such as compressed air pumped hydro to overcome problems regarding discharging, safety, and environmental pollution.[11] And the surplus energy is converted to other forms of energy such as heat or methane for storage and reconversion.[12]

[6] Since silicon absorbs light toward the red end of the visible spectrum, and perovskites can be tuned to absorb different wavelengths, coating a layer of perovskite on top of silicon cells allows combination cells to reach higher efficiencies than silicon alone.

[7] Norwegian Crystals is a Norwegian startup that manufactures low carbon monocrystalline silicon ingots for high-performance photovoltaic devices. To produce these ingots, the startup melts high-purity silicon at high temperatures using the Czochralski technique. It also produces gallium-doped ingots that increase the lifetime of the solar cells and reduce the number of stabilization steps as compared to monocrystalline silicon. Through this, Norwegian Crystals controls the carbon footprint of solar panel components at ultra-low levels, empowering consumers and businesses who consider the overall sustainability of solar energy generation.

[8] "Dess Technologies is the leading Document Management and Collaboration solutions, provider.

[9] https://evreporter.com/battery-technology-start-ups

[10] Solid-state batteries such as lithium ions store energy in solid electrode material like metal, and flow batteries store energy in electrolyte liquids. Most conventional flow batteries use two electrolyte liquids: one with a negatively charged cathode, and one with a positively charged anode.

[11] https://www.ctc-n.org/technologies/compressed-air-energy-storage-caes

[12] P2X is a technology to produce synthetic fuel and chemicals using renewable energy. The primary process of P2X is electrolysis: converting raw materials into products using electricity generated from renewable energy. This process can include water electrolysis to produce hydrogen.

3. Hydro Power

Hydropower is the power derived from the moving current of water. Hydro energy is more reliable because of its predictivity, unlike solar and wind. Besides, hydroelectric dams, as well as ocean-based energy harnessed from tides, currents, and waves, offer high energy density while reducing dependency on conventional sources. The innovations in these renewable sources focus on energy converters and component improvements for harvesting energy more efficiently. Within hydropower, small-scale hydroelectric dams and tidal barrages enable decentralized energy generation. Ocean thermal energy conversion (OETC) harnesses energy through the thermal gradient created between the surface and deep water. Few start-ups are also converting the salinity gradient formed due to the osmotic pressure difference between seawater and river into usable energy.[13]

- Iranian start-up GED Company offers microturbines for distributed generation of hydroelectricity from water streams like canals and rivers. The start-up's floating drum turbine (FDT) consists of an undershot waterwheel that floats on the water stream using a buoyant skid and is anchored with cables or hinged arms. The rotation of FDT by the stream produces electricity. The solution is low-cost, efficient, and ensures reliable distributed generation for electrification in remote and underdeveloped locations.

4. Wind Energy

Despite being one of the oldest energy resources, the rapidly evolving nature of the wind energy sector makes it one of the major trends. Startups are devising offshore and airborne wind turbines to reduce the demand for land-based wind energy.[14] Innovations in this field often integrate with other energy sources such as floating wind turbines, solar, or tidal energy. To further improve efficiency, there are constant advances in the aerodynamic designs of the blades. Startups also develop efficient generators and turbines for high energy conversion. The sustainability of blade material is one of the challenges the industry faces today. To tackle this, start-ups are creating bladeless technologies and recyclable thermoplastic materials to manufacture blades.[15]

5. Bioenergy

Bioenergy is the type of energy that is derived from biomass resources. Liquid biofuels with quality comparable to gasoline are directly blended for use in vehicles.[16] To achieve this quality, companies improve biofuels processes and upgradation techniques. Upgradation techniques like cryogenic, hydrate, in-situ, and membrane separation are used for removing sulfur and nitrogen content.[17] Similarly, the fermentation process produces bioethanol which is easy to blend directly with gasoline. Fermentation also can convert waste, food grains, and plants into bio-ethanol, thereby providing feedstock variability.[18]

6. Green Hydrogen: The Future Fuel

Hydrogen gas has the highest energy density of all fuels and produces near-zero greenhouse gas emissions. Most hydrogen is derived from non-renewable sources in the form of grey and brown hydrogen through the process called electrolysis.[19] The International Energy Agency (IEA) has pointed out that obtaining green hydrogen by this process would save 830 million tonnes of CO2 that are emitted annually when this gas is produced using fossil fuels Interestingly if this electricity is obtained from renewable sources, we would get hydrogen energy without emitting carbon dioxide into the atmosphere. In the past decade, developments in renewable energy and fuel cells have pushed the shift to green hydrogen. While cleaner, it also struggles with the problems of low energy conversion efficiency of

[13] Harvesting Energy from Ocean: Technologies and Perspectives / Review/ https:/mdpi-res.com
[14] Airborne Wind Energy Systems: A review of the technologies/ Renewable and Sustainable Energy Reviews, Volume 51, November 2015, pages 1461-1476
[15] Advanced Thermoplastic Resins for Manufacturing Wind Turbine Blades/ www.nrel.gov
[16] Petroleum fuels, such as gasoline, diesel, and jet fuel, contain a complex mixture of hydrocarbons (molecules of hydrogen and carbon), which are burned to produce energy. Hydrocarbons can also be produced from biomass sources through a variety of biological and thermochemical processes.
[17] Biogas upgrading by cryogenic techniques/ https://www.researchgate.net/publication
[18] Bio ethanol Production: An Overview/ https://www.intechopen.com/chapters
[19] This method uses an electrical current to separate the hydrogen from the oxygen in water.

fuel cells, storage, and challenges in transportation.[20] For these reasons, the developments in green hydrogen focus on improving hydrogen storage, transport, and distribution.

- Australian startup Lavo manufactures green hydrogen fuel cells that use solar energy and water to produce electricity. The startup's patented solution, *Lavo Hydrogen Battery System*, features a metal hydride storage vessel that stores hydrogen. It also contains a lithium-ion battery for fast response time, thereby making it a hybrid solution. The battery system is durable and operates under wide temperature ranges. As a result, it avoids power outages under extreme weather conditions as well as enables businesses and communities to continuously store energy for days.

Initiatives & schemes to meet Renewable Energy in India

India recently highlighted its commitments in The UN Climate Change Conference of the Parties (COP26) in Glasgow to reduce its carbon emissions. In November< Prime minister Modi Put India's five-point agenda abbreviated as Panchamrit to reiterate the country's intentions to fight global warming and climate change. By placing tremendous focus on clean sources of energy, India has laid out ambitious targets for itself and, in a way, catalyzed the world to follow suit. To achieve 500 GW of non-fossil fuel installed power generation capacity by 2030 from the current installed renewable energy capacity of 150 GW, India has a long way to go. [21]

India has seen extraordinary growth in its renewable energy sector in the past few years. In The last decade, India has provided electricity access to hundreds of millions of people residing in the last corner of the country. For its Nationally Determined Contributions as part of the Paris Agreement, India made a commitment to producing 40 percent of its total electricity from non-fossil fuel sources by 2030.[22] India's Central Electricity Authority set a target of producing 57 percent of the country's total electricity from non-fossil fuel sources by 2027 ahead of the global commitment.[23] India has also set an aim to reach its ambitious goals to produce 175 GW of renewable energy by 2022 which includes 100 GW of wind, 5 GW of small hydro, 10 GW of biomass power, and 0.168 GW of waste-to-power.[24] India increased its renewable energy target to 450 GW by 2030, with 15 times the solar and twice the wind power capacity compared to April 2016 at the United Nations Conference in 2019.[25]

- In Independence Day, Prime Minister Modi announced the launch of the National Hydrogen Mission and stated the goal to make India a global hub for Green Hydrogen production and export. The draft National Green Hydrogen Mission document is under inter-ministerial consultations.[26]
  The Mission proposes a framework for inter alia creating demand for Green Hydrogen in sectors such as petroleum refining and fertilizer production; support for indigenous manufacturing of critical technologies; Research & Development activities; and an enabling policy and regulatory framework. The proposed steps will lead to the development of additional renewable energy capacity for Green Hydrogen production.
- A tripartite Memorandum of Understanding (MoU) was signed between the Ministry of New and Renewable Energy (MNRE), the International Solar Alliance (ISA), and the World Bank for a study on the OSOWOG initiative.[27] Currently, the implementation plan, road map, and institutional framework are being developed by a consultant appointed for this purpose. The inception report has already been submitted by the consultant in September'2021. The complete study is expected to be completed by mid of 2022.
- International Solar Alliance (ISA) was launched by the Hon'ble Prime Minister of India, and the President of France on 30.11.2015 in Paris, France. With the signing and ratification of the ISA Framework Agreement by

[20] For transportation, the overarching technical challenge for hydrogen storage is how to store the amount of hydrogen required for a conventional driving range (>300 miles) within the vehicular constraints of weight, volume, efficiency, safety, and cost.
[21] https://www.outlookindia.com/website/story/business-news-five-ways-how-india-can-fuel-its-ambitious-renewable-energy-drive/403252
[22] India meets non-fossil fuel target much ahead of 2030 deadline/https://www.thehindubusinessline.com/news/india-meets-target-of-producing-over-40-of-installed-power-through-non-fossil-fuels-in-2021-against-deadline-of-2030/article38058235.ec
[23] Draft National Energy Policy, NITI Aayog, Government of India/https://www.niti.gov.in/writereaddata/files/document_publication/NEP-ID_27.06.2017.pdf
[24] India 175 GW Renewable Energy target for 2022/ https://www.iea.org/policies/6466-india-175-gw-renewable-energy-target-for-2022
[25] How close is India to meeting its renewable energy targets? / https://www.teriin.org/article/greening-grid-how-close-india-meeting-its-renewable-energy-targets
[26] A Step Forward towards National hydrogen Mission/ https://pib.gov.in/PressReleasePage.aspx?PRID=1799067
[27] Ministry of New and Renewable Energy/ https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1785808

15 countries, on 06.12.2017, ISA became the first international intergovernmental organization to be headquartered in India.[28]

- Production Linked Incentive (PLI) Scheme: On 28.04.2021, the Government introduced, the Production Linked Incentive Scheme "National Programme on High-Efficiency Solar PV Modules" with an outlay of Rs. 4500 crores to support and promote manufacturing of high-efficiency solar PV modules, including the upstage vertical components like cells, wafers, ingots, and polysilicon in India and thus reduce the import dependence in the Solar Photo Voltaic (PV) sector.[29] In pursuance of the decision, a tender for the invitation of bids for the manufacture of high-efficiency solar PV modules was issued. The tender received a very encouraging response wherein 18 bids were received which could add another around 55 GW of solar PV module manufacturing to the present solar PV module manufacturing capacity of around 11 GW. Letter of Awards has been issued by IREDA to three successful bidders for setting up 8737 MW capacity of fully integrated solar PV manufacturing units.
- Solar Parks Scheme: To facilitate large-scale grid-connected solar power projects, a scheme for "Development of Solar Parks and Ultra Mega Solar Power Projects" is under implementation with a target capacity of 40 GW capacity by March 2022. Solar parks provide solar power developers with a plug-and-play model, by facilitating necessary infrastructure like land, power evacuation facilities, road connectivity, water facility, etc. along with all statutory clearances. 52 solar parks have been sanctioned with a cumulative capacity of 37.92 GW in 14 states. Solar power projects of an aggregate capacity of around 9.2 GW have already been commissioned in these parks.[30]
- Central Public Sector Undertaking (CPSU) Scheme: A scheme for setting up 12 GW Grid- Connected Solar PV Power Projects by Central Public Sector Undertakings with domestic cells and modules is under implementation. Viability Gap Funding support is provided under this scheme. Apart from adding solar capacity, the scheme will also create demand for domestically manufactured solar cells/modules, and thus help domestic manufacturing. Under this scheme, the Government has sanctioned around 8.2 GW of projects.
- India's wind power potential at a hub height of 120 meters is 695 GW. The wind power installed capacity has grown 1.9 times during the past 7.5 years to about 40 GW and 9.67 GW of projects are at various stages of commissioning. India has the 4th largest wind power capacity in the world.
- The wind energy sector is led by the indigenous wind power industry with a strong project ecosystem, operation capabilities, and a manufacturing base of about 12 GW per annum. All the major global players in the Wind Turbine Manufacturing field have their presence in the country and over 35 different models of wind turbines are being manufactured by more than 15 different companies, through joint ventures under licensed production, subsidiaries of foreign companies, and Indian companies with their own technology. The unit size of wind turbines in India has gone up to 3.6 MW.

  The government of India has notified the Offshore Wind Energy Policy to harness the potential of offshore wind energy along India's coastline. Ministry is developing a strategy and roadmap for the installation of offshore wind projects off the coast of Gujarat and Tamil Nadu.

[28] Press Release- International Solar Alliance/ https://isolaralliance.org/media/press-release
[29] Ministry of New and Renewable Energy/ Press release/ https://pib.gov.in/pressreleaseiframepage.aspx?prid=1785808
[30] Solar parks/ accelerating the growth of solar power in india/https://mnre.gov.in/img/documents/uploads/bcf7e95e88ae4f8dbfa8bd25d21e5e12.pdf

Conclusion

Green energy is important for the environment as it replaces the negative effects of fossil fuels with more environmentally-friendly alternatives. Derived from natural resources, green energy is also often renewable and clean, meaning that they emit no or few greenhouse gases and are often readily available.

Even when the full life cycle of a green energy source is taken into consideration, they release far fewer greenhouse gases than fossil fuels, as well as few or low levels of air pollutants. This is not just good for the planet but is also better for the health of people and animals that have to breathe the air.

Green energy can also lead to stable energy prices as these sources are often produced locally and are not as affected by the geopolitical crisis, price spikes, or supply chain disruptions. The economic benefits also include job creation in building the facilities that often serve the communities where the workers are employed. Renewable energy saw the creation of 11 million jobs worldwide in 2018, with this number set to grow as we strive to meet targets such as net-zero.

Due to the local nature of energy production through sources like solar and wind power, the energy infrastructure is more flexible and less dependent on centralized sources that can lead to disruption as well as being less resilient to weather-related climate change.

Green energy also represents a low-cost solution for the energy needs of many parts of the world. This will only improve as costs continue to fall, further increasing the accessibility of green energy, especially in the developing world.