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Renewable Energy and Energy Harvesting In Himachal Pradesh and All Over India

Sanjay Sharma

Associate Professor , Physics, Govt. College, Nagrota Bagwan, Himachal Pradesh, India

ABSTRACT: Renewable energy is energy from renewable resources that are naturally replenished on a human timescale. Renewable resources include sunlight, wind, the movement of water, and geothermal heat.[2][3] Although most renewable energy sources are sustainable, some are not. For example, some biomass sources are considered unsustainable at current rates of exploitation.[4][5] Renewable energy is often used for electricity generation, heating and cooling. Renewable energy projects are typically large-scale, but they are also suited to rural and remote areas and developing countries, where energy is often crucial in human development.[6][7] Renewable energy is often deployed together with further electrification, which has several benefits: electricity can move heat or objects efficiently, and is clean at the point of consumption.[8][9]

From 2011 to 2021, renewable energy has grown from 20% to 28% of global electricity supply. Use of fossil energy shrank from 68% to 62%, and nuclear from 12% to 10%. The share of hydropower decreased from 16% to 15% while power from sun and wind increased from 2% to 10%. Biomass and geothermal energy grew from 2% to 3%. There are 3,146 gigawatts installed in 135 countries, while 156 countries have laws regulating the renewable energy sector.[10] [11] In 2021, China accounted for almost half of the global increase in renewable electricity.[12]

Globally there are over 10 million jobs associated with the renewable energy industries, with solar photovoltaics being the largest renewable employer.[13] Renewable energy systems are rapidly becoming more efficient and cheaper and their share of total energy consumption is increasing,[14] with a large majority of worldwide newly installed electricity capacity being renewable.[15] In most countries, photovoltaic solar or onshore wind are the cheapest new-build electricity.[16]

KEYWORDS: renewable , energy, harvesting, Himachal Pradesh, India, fossil, solar, wind, water

I. INTRODUCTION

Many nations around the world already have renewable energy contributing more than 20% of their total energy supply, with some generating over half their electricity from renewables.[17] A few countries generate all their electricity using renewable energy.[18] National renewable energy markets are projected to continue to grow strongly in the 2020s and beyond.[19] According to the IEA, to achieve net zero emissions by 2050, 90% of global electricity generation will need to be produced from renewable sources.[20] Some studies have shown that a global transition to 100% renewable energy across all sectors – power, heat, transport and industry – is feasible and economically viable.[21][22][23] Renewable energy resources exist over wide geographical areas, in contrast to fossil fuels, which are concentrated in a limited number of countries. Deployment of renewable energy and energy efficiency technologies is resulting in significant energy security, climate change mitigation, and economic benefits.[24] However renewables are being hindered by hundreds of billions of dollars of fossil fuel subsidies.[25] In international public opinion surveys there is strong support for renewables such as solar power and wind power.[26][27] In 2022 the International Energy Agency asked countries to solve policy, regulatory, permitting and financing obstacles to adding more renewables, to have a better chance of reaching net zero carbon emissions by 2050.[28] Renewable energy flows involve natural phenomena such as sunlight, wind, tides, plant growth, and geothermal heat, as the International Energy Agency explains:[30]

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat

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generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.

Renewable energy stands in contrast to fossil fuels, which are being used far more quickly than they are being replenished. Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits.[24] Solar and wind power have got much cheaper.[31] In some cases it will be cheaper to transition to these sources as opposed to continuing to use the current, inefficient, fossil fuels. In addition, electrification with renewable energy is more efficient and therefore leads to significant reductions in primary energy requirements. It would also reduce environmental pollution such as air pollution caused by the burning of fossil fuels, and improve public health, reduce premature mortalities due to pollution and save associated health costs that could amount to trillions of dollars annually.[33][34] Multiple analyses of decarbonization strategies have found that quantified health benefits can significantly offset the costs of implementing these strategies.[35][36] A household's solar panels, and batteries if they have them, can often either be used for just that household or if connected to an electrical grid can be aggregated with millions of others.[39] Over 44 million households use biogas made in household-scale digesters for lighting and/or cooking, and more than 166 million households rely on a new generation of more-efficient biomass cookstoves.[40][According to the research, a nation must reach a certain point in its growth before it can take use of more renewable energy. In our words, its addition changed how crucial input factors (labor and capital) connect to one another, lowering their overall elasticity and increasing the apparent economies of scale.[41] United Nations' eighth Secretary-General Ban Ki-moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity.[42] At the national level, at least 30 nations around the world already have renewable energy contributing more than 20% of energy supply.[43] Although many countries have various policy targets for longer-term shares of renewable energy these tend to be only for the power sector,[44] including a 40% target of all electricity generated for the European Union by 2030. Solar water heating makes an important contribution to renewable heat in many countries, most notably in China, which now has 70% of the global total (180 GWth). Most of these systems are installed on multi-family apartment buildings[48] and meet a portion of the hot water needs of an estimated 50–60 million households in China. Worldwide, total installed solar water heating systems meet a portion of the water heating needs of over 70 million households. In Sweden, national use of biomass energy has surpassed that of oil. Heat pumps provide both heating and cooling, and also flatten the electric demand curve and are thus an increasing priority[49][50] Renewable thermal energy is also growing rapidly.[51] About 10% of heating and cooling energy is from renewables.[47] One of the efforts to decarbonize transportation is the increased use of electric vehicles (EVs).[52] Despite that and the use of biofuels, such as biojet, less than 4% of transport energy is from renewables.[53] Occasionally hydrogen fuel cells are used for heavy transport.[54] Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, concentrated solar power (CSP), concentrator photovoltaics (CPV), solar architecture and artificial photosynthesis.[60][61] Most new renewable energy is solar.[62] Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert, and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Active solar technologies encompass solar thermal energy, using solar collectors for heating, and solar power, converting sunlight into electricity either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP).

A photovoltaic system converts light into electrical direct current (DC) by taking advantage of the photoelectric effect.[63] Solar PV has turned into a multi-billion, fast-growing industry, continues to improve its cost-effectiveness, and has the most potential of any renewable technologies together with CSP.[64][65] Concentrated solar power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Commercial concentrated solar power plants were first developed in the 1980s. CSP-Stirling has by far the highest efficiency among all solar energy technologies.

In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance

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on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared".[60] Solar power accounts for 505 GW annually, which is about 2% of the world's electricity. Solar energy can be harnessed anywhere that receives sunlight; however, the amount of solar energy that can be harnessed for electricity generation is influenced by weather conditions, geographic location and time of day.[66] According to chapter 6 of the IPCC 2022 climate mitigation report, the global potential of direct solar energy far exceeds that of any other renewable energy resource. It is well beyond the total amount of energy needed in order to support mitigation over the current century.[52] Australia has the largest proportion of solar electricity in the world, supplying 9.9% of the country's electrical demand in 2020.[67] More than 30 per cent of Australian households now have rooftop solar PV, with a combined capacity exceeding 11 GW.[68]

There are, however, environmental implications of scaling up solar energy. In particular, the demand for raw materials such as aluminum poses concerns over the carbon footprint that will result from harvesting raw materials needed to implement solar energy.[69]

Air flow can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 9 MW of rated power. The power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases up to the maximum output for the particular turbine.[75] Areas where winds are stronger and more constant, such as offshore and high-altitude sites, are preferred locations for wind farms. Typically, full load hours of wind turbines vary between 16 and 57 percent annually but might be higher in particularly favorable offshore sites.[76]

Wind-generated electricity met nearly 4% of global electricity demand in 2015, with nearly 63 GW of new wind power capacity installed. Wind energy was the leading source of new capacity in Europe, the US and Canada, and the second largest in China. In Denmark, wind energy met more than 40% of its electricity demand while Ireland, Portugal and Spain each met nearly 20%.[77]

Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand, assuming all practical barriers needed were overcome. This would require wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore, and likely also industrial use of new types of VAWT turbines in addition to the horizontal axis units currently in use. As offshore wind speeds average ~90% greater than that of land, offshore resources can contribute substantially more energy than land-stationed turbines.[78]

In a recent meeting of the Energy Department, Chief Minister Thakur Sukhvinder Singh Sukhu announced the government’s intention to formulate a new Energy Policy, with the primary objective of securing a larger share for Himachal Pradesh in various hydropower projects. The proposed policy entails significant changes, including the complete abolition of the provision for deferment of free power royalty, along with revised revenue sharing arrangements. Under the new policy framework, the state government seeks to enhance its share of revenue from hydropower projects. Currently, the provision allows for a 12 percent share during the initial 12 years, followed by 18 percent for the subsequent 18 years, and a consistent 30 percent for the final 10 years. However, the proposed revisions call for an increased share, with a provision of 15 percent for the first 12 years, 20 percent for the subsequent 18 years, and 30 percent for the final 10 years.

Chief Minister Sukhu expressed determination to explore opportunities for expanding the state’s share in projects that have already recovered their costs. To achieve this, he announced plans to initiate correspondence with the Central Government and other Public Sector Undertakings (PSUs). Furthermore, the government intends to grant land leases for a period of forty years for all upcoming hydropower projects, in accordance with the policy guidelines. During the meeting, Chief Minister Sukhu voiced concerns regarding delays in the implementation of hydro power projects by central PSUs. He instructed the Energy Department to issue notices to address the non-compliance of pre-implementation and implementation agreements. Additionally, he emphasized the need to streamline the process of obtaining No Objection Certificates (NOCs) for the construction of hydro power projects.

Highlighting the significance of timely project execution, Chief Minister Sukhu cited the state's existing portfolio of 172 commissioned hydropower projects, with a cumulative capacity of 11,149.50 MW, along with 58 ongoing projects with a capacity of 2,454 MW. He stressed the importance of minimizing unnecessary delays and urged the Energy Department to establish a robust monitoring mechanism. Delays, he cautioned, lead to financial losses for the state exchequer. To enhance efficiency, the Directorate of Energy will be strengthened, and artificial intelligence will be leveraged to optimize departmental operations.

Chief Minister Sukhu expressed disappointment over certain hydro power projects that have yet to commence construction despite availing themselves of a one-time amnesty. To rectify this, he called for the immediate cancellation of project allotments in such cases, followed by the publication of fresh advertisements. Emphasizing the critical role of power generation as a primary source of state revenue, he asserted that any potential losses to the state exchequer would not be tolerated. In addition to addressing hydropower projects, the Chief Minister also reviewed the progress of solar projects being undertaken in the state. With a target of initiating 500 MW of solar power projects this year, he urged the department to expedite construction efforts.

The meeting witnessed the presence of prominent officials, including Industries Minister Harshwardhan Chauhan, Principal Advisor to the Chief Minister Ram Subhag Singh, Chief Secretary Prabodh Saxena, Principal Secretary to Chief Minister Bharat Khera, Secretary MPP & Power Rajeev Sharma, OSD to the Chief Minister Gopal Sharma, Director of the Energy Department Harikesh Meena, and other senior officers.

II. DISCUSSION

Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. Water can generate electricity with a conversion efficiency of about 90%, which is the highest rate in renewable energy.[82] There are many forms of water energy:

- Historically, hydroelectric power came from constructing large hydroelectric dams and reservoirs, which are still popular in developing countries.[83] The largest of them are the Three Gorges Dam (2003) in China and the Itaipu Dam (1984) built by Brazil and Paraguay.
- Small hydro systems are hydroelectric power installations that typically produce up to 50 MW of power. They are often used on small rivers or as a low-impact development on larger rivers. China is the largest producer of hydroelectricity in the world and has more than 45,000 small hydro installations.[84]
- Run-of-the-river hydroelectricity plants derive energy from rivers without the creation of a large reservoir. The water is typically conveyed along the side of the river valley (using channels, pipes and/or tunnels) until it is high above the valley floor, whereupon it can be allowed to fall through a penstock to drive a turbine. A run-of-river plant may still produce a large amount of electricity, such as the Chief Joseph Dam on the Columbia River in the United States.[85] However many run-of-the-river hydro power plants are micro hydro or pico hydro plants.

Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. Of the top 50 countries by percentage of electricity generated from renewables, 46 are primarily hydroelectric.[86] Much hydropower is flexible, thus complementing wind and solar.[87] Wave power, which captures the energy of ocean surface waves, and tidal power, converting the energy of tides, are two forms of hydropower with future potential; however, they are not yet widely employed commercially.[88] A demonstration project operated by the Ocean Renewable Power Company on the coast of Maine, and connected to the grid, harnesses tidal power from the Bay of Fundy, location of the world's highest tidal flow. Ocean thermal energy conversion, which uses the temperature difference between cooler deep and warmer surface waters, currently has no economic feasibility.[89][90] Biomass is biological material derived from living, or recently living organisms. It commonly refers to plants or plant-derived materials. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel in solid, liquid or gaseous form. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical methods. Wood was the largest biomass energy source as of 2012;[94] examples include forest residues – such as dead trees, branches and tree stumps, yard clippings, wood chips and even municipal solid waste. Industrial biomass can be grown from numerous types of plants, including miscanthus, switchgrass, hemp, corn, poplar, willow, sorghum, sugarcane, bamboo,[95] and a variety of tree species, ranging from eucalyptus to oil palm (palm oil).

Plant energy is produced by crops specifically grown for use as fuel that offer high biomass output per hectare with low input energy.[96] The grain can be used for liquid transportation fuels while the straw can be burned to produce heat or electricity. Plant biomass can also be degraded from cellulose to glucose through a series of chemical treatments, and the resulting sugar can then be used as a first-generation biofuel.

Biomass can be converted to other usable forms of energy such as methane gas[97] or transportation fuels such as ethanol and biodiesel. Rotting garbage, and agricultural and human waste, all release methane gas – also called landfill gas or biogas. Crops, such as corn and sugarcane, can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products such as vegetable oils and animal fats.[98] There is a great deal of research involving algal fuel or algae-derived biomass due to the fact that it is a non-food resource, grows around 20 times faster than other types of food crops, such as corn and soy, and can be grown almost anywhere.[99][100] Once harvested, it can be fermented to produce biofuels such as ethanol, butanol, and methane, as well as biodiesel and hydrogen. The biomass used for electricity generation varies by region. Forest by-products, such as wood residues, are common in the United States. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (rice husks).

Biofuels include a wide range of fuels which are derived from biomass. The term covers solid, liquid, and gaseous fuels.[101] Liquid biofuels include bioalcohols, such as bioethanol, and oils, such as biodiesel. Gaseous biofuels include biogas, landfill gas and synthetic gas. Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. These include maize, sugarcane and, more recently, sweet sorghum. The latter crop is particularly suitable for growing in dryland conditions, and is being investigated by International Crops Research Institute for the Semi-Arid Tropics for its potential to provide fuel, along with food and animal feed, in arid parts of Asia and Africa.[102]

With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstocks for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the United States and in Brazil. The energy costs for producing bio-ethanol are almost equal to, the energy yields from bio-ethanol. However, according to the European Environment Agency, biofuels do not address global warming concerns.[103] Biodiesel is made from vegetable oils, animal fats or recycled greases. It can be used as a fuel for vehicles in its pure form, or more commonly as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe. Biofuels provided 2.7% of the world's transport fuel in 2010.[104][

Biomass, biogas and biofuels are burned to produce heat/power and in doing so can harm the environment. Pollutants such as sulphurous oxides (SO_x), nitrous oxides (NO_x), and particulate matter (PM) are produced from the combustion of biomass. With regards to traditional use of biomass for heating and cooking, the World Health Organization estimates that 3.7 million prematurely died from outdoor air pollution in 2012 while indoor pollution from biomass burning effects over 3 billion people worldwide.[105][106] High temperature geothermal energy is from thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet and from radioactive decay of minerals (in currently uncertain[110] but possibly roughly equal[111] proportions). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. The adjective geothermal originates from the Greek roots geo, meaning earth, and thermos, meaning heat.

The heat that is used for geothermal energy can be from deep within the Earth, all the way down to Earth's core – 6,400 kilometres (4,000 mi) down. At the core, temperatures may reach over 5,000 °C (9,030 °F). Heat conducts from the core to the surrounding rock. Extremely high temperature and pressure cause some rock to melt, which is commonly known as magma. Magma convects upward since it is lighter than the solid rock. This magma then heats rock and water in the crust, sometimes up to 371 °C (700 °F).[112]

Low temperature geothermal[49] refers to the use of the outer crust of the Earth as a thermal battery to facilitate renewable thermal energy for heating and cooling buildings, and other refrigeration and industrial uses. In this form of geothermal, a geothermal heat pump and ground-coupled heat exchanger are used together to move heat energy into the Earth (for cooling) and out of the Earth (for heating) on a varying seasonal basis. Low-temperature geothermal (generally referred to as "GHP"[is an increasingly important renewable technology because it both reduces total annual energy loads associated with heating and cooling, and it also flattens the electric demand curve eliminating the extreme summer and winter peak electric supply requirements. Thus low temperature geothermal/GHP is becoming an increasing nationalpriority with multiple tax credit support[113] and focus as part of the ongoing movement toward net zero energy.[50] Solar thermal energy (STE) is a form of energy and a technology for harnessing solar energy to generate thermal energy for use in industry, and in the residential and commercial sectors.

Solar thermal collectors are classified by the United States Energy Information Administration as low-, medium-, or high-temperature collectors. Low-temperature collectors are generally unglazed and used to heat swimming pools or to heat ventilation air. Medium-temperature collectors are also usually flat plates but are used for heating water or air for residential and commercial use.

High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for fulfilling heat requirements up to 300 deg C / 20 bar pressure in industries, and for electric power production. Two categories include Concentrated Solar Thermal (CST) for fulfilling heat requirements in industries, and Concentrated Solar Power (CSP) when the heat collected is used for electric power generation. CST and CSP are not replaceable in terms of application.

The largest facilities are located in the American Mojave Desert of California and Nevada. These plants employ a variety of different technologies. The largest examples include, Ouarzazate Solar Power Station in Morocco (510 MW), Ivanpah Solar Power Facility (377 MW), Solar Energy Generating Systems installation (354 MW), and Crescent Dunes (110 MW). Spain is the other major developer of solar thermal power plants. The largest examples include, Solnova Solar Power Station (150 MW), the Andasol solar power station (150 MW), and Extresol Solar Power Station (100 MW).

H.P Solar Power Policy - 2016

Strengthen and sustain the Policy of 100% clean electricity consumption in the State, by providing a suitable alternative to coal and gas based power and to provide firm base load power during the sunshine time of the day , so that water in the hydro projects are impounded during day time for peaking power.Empower people in the remote and rural areas with 24x7 powers by way of decentralised solar power supply, especially in the unreliable grid systems in the mountains, to meet their basic needs, enable access to social and commercial services, and technologies.Contribute to macro policies and strategies on climate change, environment protection and sustainable development.Promote investment, mainly private, so as to derive benefits of jobs, incomes, revenues and growth.Facilitate achieving RPPO by capacity creations in the State

Hydro Power Policy 2006 in Himachal Pradesh

1. To speed up the Power Development in the State and achieve capacity addition.
2. To generate and provide employment opportunities to the people of the Himachal Pradesh.
3. To make Power sector a major source of revenue to the State.

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4. To secure long term financial interests of the State.
5. To achieve financial turnaround and commercial viability of Power Sector.
6. To develop local area by creation of Local Area Development Committee financed through Power Projects.
7. To establish and promote Power trading entity in the State.
8. To provide indiscriminate access of the electricity to all the households in the State in the immediate near future and to protect the interest of consumers.
9. To make available reliable, regular and quality Power on demand at affordable rates in the immediate near future.
10. To promote & provide continued support for development of renewable energy sources like SHPs, Solar, Biomass, Water Mills etc;

III. RESULTS

There are also other renewable energy technologies that are still under development, including cellulosic ethanol, hot-dry-rock geothermal power, and marine energy.[114] These technologies are not yet widely demonstrated or have limited commercialization. Many are on the horizon and may have potential comparable to other renewable energy technologies, but still depend on attracting sufficient attention and research, development and demonstration (RD&D) funding.[114]

There are numerous organizations within the academic, federal, and commercial sectors conducting large-scale advanced research in the field of renewable energy. This research spans several areas of focus across the renewable energy spectrum. Most of the research is targeted at improving efficiency and increasing overall energy yields.[115] Multiple government supported research organizations have focused on renewable energy in recent years. Two of the most prominent of these labs are Sandia National Laboratories and the National Renewable Energy Laboratory (NREL), both of which are funded by the United States Department of Energy and supported by various corporate partners.[116] Enhanced geothermal systems (EGS) are a new type of geothermal power technology that does not require natural convective hydrothermal resources. The vast majority of geothermal energy within drilling reach is in dry and non-porous rock.[117] EGS technologies "enhance" and/or create geothermal resources in this "hot dry rock (HDR)" through hydraulic fracturing. EGS and HDR technologies, such as hydrothermal geothermal, are expected to be baseload resources that produce power 24 hours a day like a fossil plant. Distinct from hydrothermal, HDR and EGS may be feasible anywhere in the world, depending on the economic limits of drill depth. Good locations are over deep granite covered by a thick (3–5 km or 1.9–3.1 mi) layer of insulating sediments which slow heat loss.[118] There are HDR and EGS systems currently being developed and tested in France, Australia, Japan, Germany, the U.S., and Switzerland. The largest EGS project in the world is a 25 megawatt demonstration plant currently being developed in the Cooper Basin, Australia. The Cooper Basin has the potential to generate 5,000–10,000 MW. Marine energy (also sometimes referred to as ocean energy) is the energy carried by ocean waves, tides, salinity, and ocean temperature differences. The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. This energy can be harnessed to generate electricity to power homes, transport and industries. The term marine energy encompasses wave power – power from surface waves, marine current power - power from marine hydrokinetic streams (e.g., the Gulf Stream), and tidal power – obtained from the kinetic energy of large bodies of moving water. Reverse electrodialysis (RED) is a technology for generating electricity by mixing fresh river water and salty sea water in large power cells designed for this purpose; as of 2016, it is being tested at a small scale (50 kW). Offshore wind power is not a form of marine energy, as wind power is derived from the wind, even if the wind turbines are placed over water. The oceans have a tremendous amount of energy and are close to many if not most concentrated populations. Ocean energy has the potential of providing a substantial amount of new renewable energy around the world. Passive daytime radiative cooling (PDRC) uses the coldness of outer space as a renewable energy source to achieve daytime cooling that can be used in many applications,[124][125][126] such as indoor space cooling,[127][128] outdoor urban heat island mitigation,[129][130] and solar cell efficiency.[131][132] PDRC surfaces are designed to be high in solar reflectance to minimize heat gain and strong in longwave infrared (LWIR) thermal radiation heat transfer.[133] On a planetary scale, it has been proposed as a way to slow and reverse global warming.[123][134] PDRC applications are deployed as sky-facing surfaces, similar to other renewable energy sources such as photovoltaic systems and solar

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thermal collectors.[132] PDRC became possible with the ability to suppress solar heating using photonic metamaterials, first published in a study by Raman et al. to the scientific community in 2014.[135][136] PDRC applications for indoor space cooling is growing with an estimated "market size of ~$27 billion in 2025. Artificial photosynthesis uses techniques including nanotechnology to store solar electromagnetic energy in chemical bonds by splitting water to produce hydrogen and then using carbon dioxide to make methanol.[138] Researchers in this field strived to design molecular mimics of photosynthesis that use a wider region of the solar spectrum, employ catalytic systems made from abundant, inexpensive materials that are robust, readily repaired, non-toxic, stable in a variety of environmental conditions and perform more efficiently allowing a greater proportion of photon energy to end up in the storage compounds, i.e., carbohydrates (rather than building and sustaining living cells).[139] However, prominent research faces hurdles, Sun Catalytix a MIT spin-off stopped scaling up their prototype fuel-cell in 2012 because it offers few savings over other ways to make hydrogen from sunlight. Earth emits roughly 10^{17} W of infrared thermal radiation that flows toward the cold outer space. Solar energy hits the surface and atmosphere of the earth and produces heat. Using various theorized devices like emissive energy harvester (EEH) or thermoradiative diode, this energy flow can be converted into electricity. In theory, this technology can be used during nighttime.[141][142]

Producing liquid fuels from oil-rich (fat-rich) varieties of algae is an ongoing research topic. Various microalgae grown in open or closed systems are being tried including some systems that can be set up in brownfield and desert lands.[143] Collection of static electricity charges from water droplets on metal surfaces is an experimental technology that would be especially useful in low-income countries with relative air humidity over 60%.[144] AuREUS devices (Aurora Renewable Energy & UV Sequestration),[145] which are based on crop wastes can absorb ultraviolet light from the sun and turn it into renewable energy.[146][147] Renewable energy production from some sources such as wind and solar is more variable and more geographically spread than technology based on fossil fuels and nuclear. While integrating it into the wider energy system is feasible, it does lead to some additional challenges such as increased production volatility and decreased system inertia.[148] Implementation of energy storage, using a wide variety of renewable energy technologies, and implementing a smart grid in which energy is automatically used at the moment it is produced can reduce risks and costs of renewable energy implementation.[148][149]

Sector coupling of the power generation sector with other sectors may increase flexibility: for example the transport sector can be coupled by charging electric vehicles and sending electricity from vehicle to grid.[150] Similarly the industry sector can be coupled by hydrogen produced by electrolysis,[151] and the buildings sector by thermal energy storage for space heating and cooling.[152] Electrical energy storage is a collection of methods used to store electrical energy. Electrical energy is stored during times when production (especially from intermittent sources such as wind power, tidal power, solar power) exceeds consumption, and returned to the grid when production falls below consumption. Pumped-storage hydroelectricity accounts for more than 85% of all grid power storage.[153] Batteries are increasingly being deployed for storage[154] and grid ancillary services[155] and for domestic storage.[156] Green hydrogen is a more economical means of long-term renewable energy storage, in terms of capital expenditures compared to pumped hydroelectric or batteries.[157][158] Most new renewables are solar, followed by wind then hydro then bioenergy.[159] Investment in renewables, especially solar, tends to be more effective in creating jobs than coal, gas or oil.[160][161] Worldwide, renewables employ about 12 million people as of 2020, with solar PV being the technology employing the most at almost 4 million.[162] The results of a recent review of the literature concluded that as greenhouse gas (GHG) emitters begin to be held liable for damages resulting from GHG emissions resulting in climate change, a high value for liability mitigation would provide powerful incentives for deployment of renewable energy technologies.[174]

In the decade of 2010–2019, worldwide investment in renewable energy capacity excluding large hydropower amounted to US$2.7 trillion, of which the top countries China contributed US$818 billion, the United States contributed US$392.3 billion, Japan contributed US$210.9 billion, Germany contributed US$183.4 billion, and the United Kingdom contributed US$126.5 billion.[175] This was an increase of over three and possibly four times the equivalent amount invested in the decade of 2000–2009 (no data is available for 2000–2003).[175]

As of 2022, an estimated 28% of the world's electricity was generated by renewables. This is up from 19% in 1990.[176]

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Small Hydro Development Programme in Himachal Pradesh

Private Sector participation
The State Government has taken several initiatives to encourage private sector participation in small hydro power development. Himachal Pradesh is among the few States, which has streamlined and is continuously refining the various procedures/processes to minimize the bottlenecks.The process of exploitation of hydel potential in small hydro sector through private sector participation began during 1995-96. Since then, the allotment of project sites has been a continuous process. Till 30th November, 2011, 468 Small hydro Electric Projects (upto 5MW capacity) with an aggregate capacity of 1176 MW have been allotted. Out of these 45 projects with an aggregate capacity of 177.55 MW have been commissioned. A goal of 500 MW through Small Hydel Projects by the end of 2014 has been fixed.
Projects to be offered for private sector participation
Projects up to 5.00 MW are handled by Himachal Pradesh Government Energy Development Agency (HIMURJA) in following modes.

- Projects Identified by HHIMURJA.
- Projects Identified by the interest private parties designated as self identified projects.
  - Small Hydro Project up to 2.00 MW capacity shall be exclusively reserved for the Himachalis. Whereas while allotting projects upto 5.00 MW, Himachali shall be given extra 30 marks in addition to the marks obtained by them for financial strength.
  - Not more than 3 projects shall be allotted for implementation to an IPP including the already allotted projects.

IV. CONCLUSIONS

A December 2022 report by the IEA forecasts that over 2022-2027, renewables are seen growing by almost 2 400 GW in its main forecast, equal to the entire installed power capacity of China in 2021. This is an 85% acceleration from the previous five years, and almost 30% higher than what the IEA forecast in its 2021 report, making its largest ever upward revision. Renewables are set to account for over 90% of global electricity capacity expansion over the forecast period.[177] To achieve net zero emissions by 2050, IEA believes that 90% of global electricity generation will need to be produced from renewable sources.[20]

In June 2022 IEA Executive Director Fatih Birol said that countries should invest more in renewables to "ease the pressure on consumers from high fossil fuel prices, make our energy systems more secure, and get the world on track to reach our climate goals."[178]China's five year plan to 2025 includes increasing direct heating by renewables such as geothermal and solar thermal.[179]REPowerEU, the EU plan to escape dependence on fossil Russian gas, is expected to call for much more green hydrogen.[180]After a transitional period, renewable energy production is expected to make up most of the world's energy production. In 2018, the risk management firm, DNV GL, forecasts that the world's primary energy mix will be split equally between fossil and non-fossil sources by 2050.[181]

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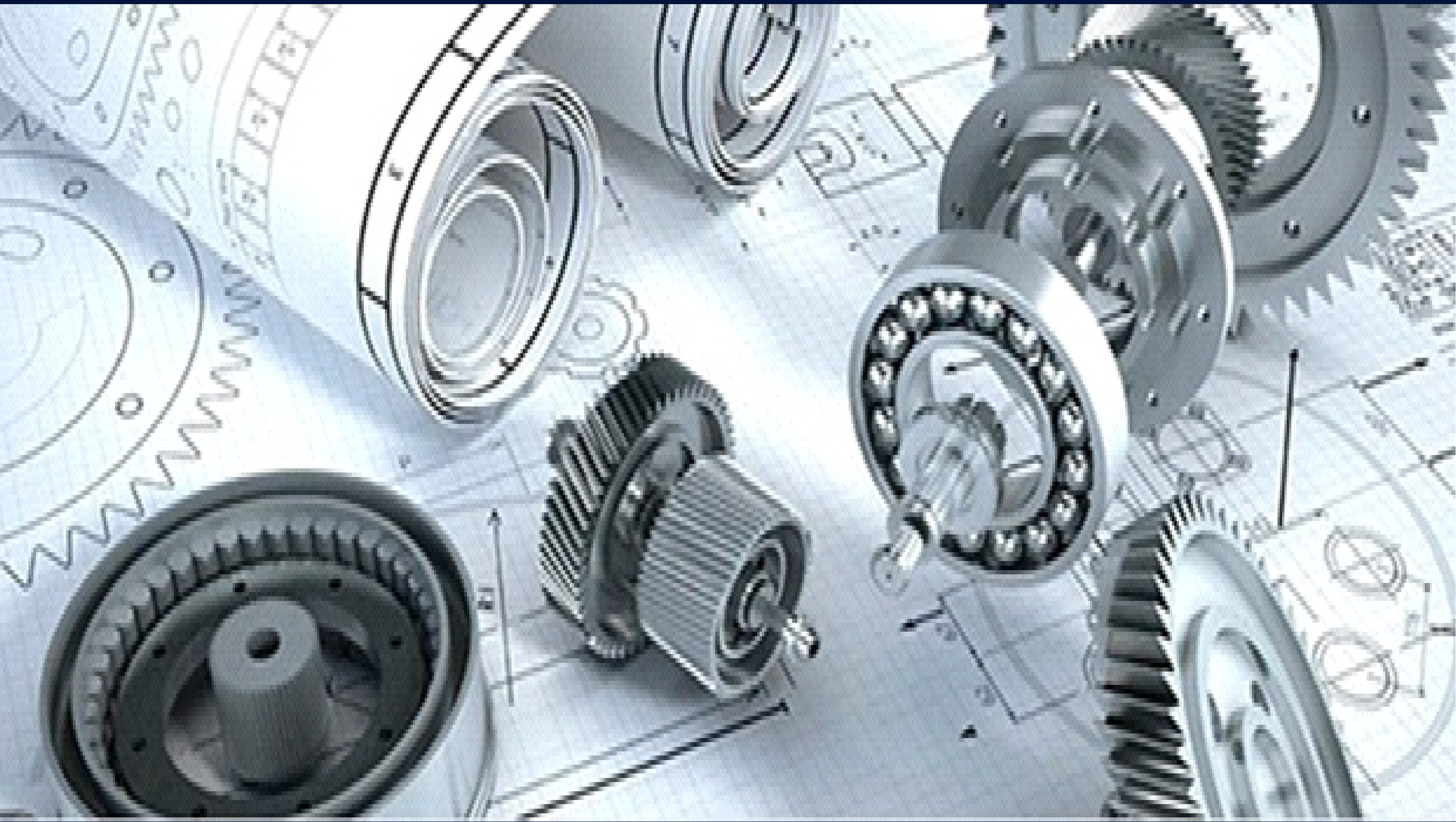

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+91 99405 72462 +91 63819 07438 ijmrsetm@gmail.com