# A Survey of Renewable Energy Sources and their Contribution to Sustainable Development

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**Abstract** – Many nations must undergo economic growth, and this will inevitably lead to a rise in population, both of which will have consequences for the natural environment. This is due to the fact that producing energy (whether for electricity, cooling, heating or power for transportation motors and other applications) is an ecologically inefficient and wasteful activity that contributes to pollution. Considered crucial to the creation of prosperity, energy is widely recognized as an important factor in economic growth. It has a crucial role in alleviating poverty and fostering long-term growth. It has a beneficial impact on social, economic, and environmental development in areas such as livelihoods, water availability, agricultural production, health, population levels, educational equity, and addressing the needs of women and girls. Due to this, energy resources are crucial for every nation on Earth. This paper provides a discussion of the benefits to the economy, environmental effects (including on global warming), pros and cons, and methods for optimal utilization with regards to renewable energy sources and their role in sustainable development.

**Keywords –** Renewable Energy, Sustainable Development, Solar Energy, Wind Energy, Biomass Energy, Hydropower.

## I. INTRODUCTION

Efforts to achieve sustainable development and decrease poverty rely heavily on access to affordable energy. Cultural, socioeconomic, and biological conditions such as livelihoods, the availability of water, health, agricultural production, education, population numbers and gender-based concerns are all affected. It's safe to say that the majority of the world's pressing environmental, economic and development issues can be traced back to the globe's energy architecture. Services within the energy field that are dependable, economical, and efficient and clean are crucial to economic growth on a worldwide scale. If they want to alleviate poverty, enhance the health of their inhabitants, boost productivity, remain competitive, and stimulate economic development, developing nations must increase access to dependable and modern energy services. According to Hickmann et al. [1], Millennium Development Goals (MDGs) are at risk because current energy systems cannot fulfill the demands of the world's poor. For instance, both schools and medical facilities cannot operate adequately without consistent electricity. A lack of efficient pumping capacity severely limits people's accessibility to proper sanitation and safe drinking water. Negative effects on food security have serious consequences, especially for disadvantaged communities. Roughly 3 billion individuals throughout the globe make use of traditional biomass for heating and cooking, while approximately 1.5 billion do not have accessibility to electricity.

There may be as many as a billion people who rely only on unreliable electrical networks. Ineffective combustion of solid fuels in poorly ventilated constructions has serious health repercussions for the "energy-poor," as does a lack of electricity for income-generating activities and other necessities like healthcare and education. Girls and women in the underdeveloped nations are disproportionately affected by this. The globe's poorest few billion individuals would have a better opportunity to evade poverty with the assistance of fully functional energy architecture, which enhances effective accessibility to modern types of energy. Reaching broader development goals also requires such a system. Accessibility to modern energy services is correlated to economic development, particularly in medium and low-income countries through the era of fast industrial developments. According to Schroeder, Costa, and Obé [2], electrical blackouts, overinvestment in backup power sources, fuel loses, and subsidies and wasteful employment of finite energy resources may cost nations between 0.1 and 0.2 percentage points of their yearly development potential. About 60% of all current greenhouse gas (GHG) emissions come from the energy system, which includes supply, transformation, distribution, and usage on a global scale.

According to Do and Cetin [3], the current energy consumption and generation patterns pose a serious danger to the environment on a global and local scale and cannot be maintained. The burning of fossil fuels releases harmful byproducts that contribute to a number of environmental problems, including global warming, acidification of land and water, and increased levels of air pollution in cities. Achieving long-term climate objectives requires a focus on lowering the intensity of carbon use in energy production, or the amount of carbon that is produced in every kilowatt/hour of energy generated. As long as fossil fuels continue to make up a disproportionate share of the energy mix, this goal will remain elusive using conventional energy sources. In case the supply, usage and conversion of energy continue to remain inefficient, the world's use of energy will expand dramatically as the global economy is forecasted to double in size over the next two decades.

Consequently, the danger of irreversible, catastrophic climate change may be mitigated in large part by the design of energy systems that provide better incentives for decreased emission of GHG in supply and increased end-use effectiveness. Resultantly, the United Nations Secretary General organized the Advisory Group on Energy and Climate Change (AGECC) to discuss how to simultaneously fulfill the globe’s energy demands for development whereas making a significant contribution to a decrease in greenhouse gas emissions. Because of factors such as the vulnerability of the global economy to spikes in the prices of energy, increasing competition for finite natural resources and the imperative to accelerate the development towards the achievement of MDG. AGECC accomplished its work in a rapidly evolving context in which energy often played a central role. What the world does to combat climate change will have an effect on all of these problems. The secretary general has assembled a high-level advisory committee on Climate Change Financing to implement the Copenhagen Accord, which was adopted at the UNFCCC committee in December 2009.

According to Chen, Lee, and Kang [4], there is no risk-free energy source; thus, economic and environmental considerations must be addressed simultaneously when selecting energy sources. Modern efforts to curb pollution and preserve the natural world extend much beyond individual nations. Growing reliance on fossil fuels (such as natural gas, coal, and petroleum) poses concerns that must be mitigated. Energy supplies that produce fewer dangerous gases into the environment (such Carbon-dioxide ($CO_2$) should be favored in addition to renewable sources of energy in order to lower such dangers and maximize energy production. If we do not do anything, we're dooming future generations to ecological collapse and catastrophes. Renewable sources of energy have less adverse effects on the environment compared to traditional energy sources. Renewable energy sources have lower production costs than those of a fossil fuel origin. In spite of the vastness of the renewable energy field, this study focuses on only a few: solar, wind, biofuel, and hydropower. Benefits to the economy, environmental effects (including on global warming), pros and cons, and methods for optimal utilization are discussed in this study with regards to renewable energy sources and their role in sustainable development.

The rest of the paper is organized as follows: Section II focuses on a survey of the solar energy. In this section, different aspects are discussed: economic advantages for sustainable development, solar PV global condition report, environmental effects of solar energy, approaches for optimum exploitations of solar energy, advantages and disadvantages of solar energy. Section III surveys wind energy providing discussions in the economic advantages for sustainable development, wind port status report, environmental images of wind energy, approaches for optimum exploitations of wind energy, and advantages and disadvantages of wind energy. Section IV focuses on a discussion about biomass energy, where details of the economic advantages for sustainable development, bio-power status report, and environmental impacts of biomass are provided. Section V focuses on hydropower, and discusses the economic advantages of sustainable development, the concept of hydro-power status report, and the environmental impacts of hydro-power. Section VI discusses geothermal energy, providing details about the economic advantages for sustainable development, geothermal power, environmental impacts of geothermal energy, and advantages and disadvantages of geothermal energy. The last Section VII presents a summary of the research findings.

## II. SOLAR ENERGY

With rising energy demands and public awareness of environmental issues, it's time to look at renewable alternatives to damaging fossil fuels. Solar energy is the energy of the sun that is captured from afar, most often on Earth. The sun turns over 650 M hydrogen tons into helium each second in the thermo-nuclear process that releases energy [5]. It generates thermal energy and electromagnetic radiation. The sun retains this heat, which is crucial to keeping the thermo-nuclear process developing. Electromagnetic radiation (that integrates infrared light, visible light, and ultra-violet radiation) is emitted in different directions. Electromagnetic radiation (which includes visible light, infrared light, and ultraviolet radiation) is emitted in all directions and travels across space. To put it simply, the amount of radiation that actually reaches Earth is negligible. What little radiation does reach Earth is the indirect source of practically all forms of energy utilized today. With the exclusion of nuclear fusion and fission, all other types of energy generation are fossil fuel based.

The sun is responsible for everything we use, including fossil fuels, which were once sun-dependent organisms. It takes two things to make solar energy work: something to gather the sunlight and something to convert some of that sunlight into usable forms of energy (either electricity and heat or heat alone). The need for the battery bank arises from the intermittent nature of solar power, when only a tiny quantity of radiation is received. Energy generator output drops, for example, when the sun is not out or when there are plenty of clouds around. A collector and a storage device are the two parts in question. The collector's footprint, if defined only by the collector, will be tiny. The storage unit may collect surplus energy during times of high production and then release it when output decreases. In fact, a secondary power source is often included as well, in case the quantity of energy needed exceeds the combined output from the generator and the capacity of the storage unit.

Solar is one of the cleanest and most sustainable energy sources available. The sun's constant rays are what keep life going on Earth. Taking use of this energy in a methodical manner might make it the single most important source of power; using only one percent of the power available from the sun's beams on Earth would end the world's energy issue. But the potential of solar energy is around 750GW in India according to a study by Kumar Singh, Prasath Kumar, and Krishnaraj [6]. Using this energy would eliminate the need for any additional power plants in the nation. Photovoltaic cells (also known as solar cells) and focused solar power (where sun rays are focused and the concentrated power provides heat to operate the solar plant) are two of the most popular methods for transforming solar energy into electricity. The depletion of nonrenewable resources has made solar power more important during the last decade. India plans to add another 10K MW by 2017 and 100K MW by 2022, bringing the total installed grid linked solar power capacity to 4,060.65 MW as of 30 June 2015.

India was the first nation to establish a ministry dedicated to developing alternative energy sources, and the state of Gujarat has been in the forefront of solar power production, accounting for around two-thirds of the 900 MW of photovoltaic capacity in the whole country. There have been several government-sponsored attempts to boost residential solar energy usage, such as the Indian Solar Loan Programme's emphasis on solar home power system financing. Lighting, irrigation, and water heaters are additional possibilities. The biggest number of solar water heaters in India is located in the city of Bangalore. According to Verma, Kumar, Rakshit, and Premachandran [7], 2015 was also notable for the solar industry's record-breaking $119 billion in new investment. In fact, more than 88% of India's solar energy comes from only two states, Gujarat and Rajasthan. Since the whole globe is trending toward reducing the usage of renewable energy and favoring solar gadgets, the possibilities for innovation in this field are almost limitless for business owners. We are quickly approaching a day when solar-powered vehicles, homes, and gadgets are the norm. Furthermore, since solar cell efficiency is less than 10%, there is enormous room for developers to produce energy efficient photovoltaic devices while also making it cost-effective to satisfy the needs of the massive population in our nation.

Between 0.3 and 2.5 micrometers, the solar spectrum provides the Earth with maximum flux density of approximately 1.0 kWm2. The visible spectrum is part of what is known as short wave radiation. This flux ranges from approximately 3 – 30 MJm2 for the first day for populated regions, based on the location, weather condition, and time of the day. The thermodynamic quality of this energy flow is very good, and it comes from a readily available source with temperatures orders of magnitude higher than those achieved by traditional engineering methods. The flux has several applications, including thermal (for heat engines) and photochemical and photo-physical (for solar electricity and photosynthesis, for example). The amount of energy that may be harvested from the sun per square meter of surface area on Earth ranges from zero to one thousand and ten watts (W/m2). Solar power has no downsides, no fixed costs, and infinite potential. In the past, solar energy was only utilized to provide heat; now, with the advent of more advanced technology, it has also become a viable source of electrical power. Solar cells and photovoltaic (PV) cells are used to generate electricity, although their effectiveness gradually declines over the day.

### *Economic Advantages for Sustainable Development*

The PV generating model plays a vital part in the general electrical energy demands in developing countries, and solar photovoltaic energy has a higher interest due to its renewable nature, environmental friendliness, and adaptability in terms of installation. Solar power doesn't deplete natural resources and doesn't harm the environment, so it's a great option. Solar energy, which was not deemed affordable only a few years ago due to the surge in fuel costs observed in recent years, has become quite inexpensive in most locations. Solar energy has great potential as an environmentally friendly replacement for traditional energy sources like fossil fuels. Both passive solar heating, in which a building is oriented to the sun, and vibrant solar heating, where a liquid such as water is pumped through rooftop gatherers, are viable options for heating a building (active solar heating). Solar thermal systems are able to capture the sun's rays and turn them into usable heat or even power. This method is often used in sunny desert environments. There is hope that the expensive cost of installing solar cells that convert sunlight into energy may decrease in the future since these cells can be integrated into roofing materials or windows.

### *Solar PV: Global Condition Report*

In 2016, approximately 9.8 million individuals were employed in the renewable energy industry, a rise of 1.1% from the previous year. The greatest number of employments was generated by solar photovoltaics and biofuels, respectively. 62% of all employment in renewable energy (excluding large-scale hydropower) has moved to Asia, with China at the forefront of this trend. More than 31K solar panels were installed in every in 2016, contributing to the global increase in solar PV capacity of at least 75 GWdci. In 2016, solar PV installations increased by 48% over the previous year, surpassing the global total from the previous five years. Worldwide solar photovoltaic capacity reached at least 303 GW by the end of the year. In 2018, the yearly worldwide market for solar photovoltaics (PV) grew little, but enough to surpass 100 GWi limit (both offgrid and on-grid capacity) [8]. The cumulative capability increased by approximately 25% to about 505 GW, up from the global overall of approximately 15 GW just a decade ago see **Fig 1**. Despite repercussions all over the globe from China's market fall, it was offset by rising demand in developing countries and Europe as a result of persistent price cuts.

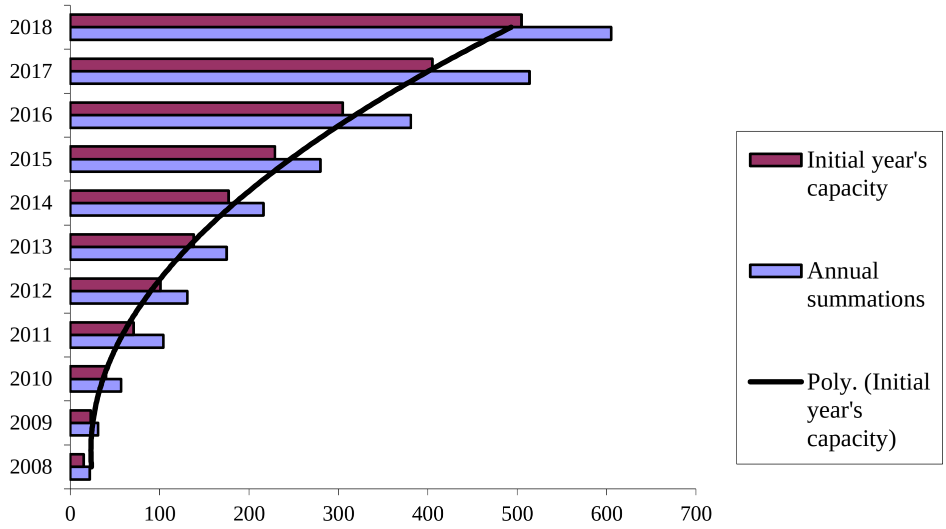


**Fig 1.** Solar PV Annual Additions and Global Capacity From 2008 To 2018

*Environmental Effects of Solar Energy*

In contrast to certain potentially harmful power producing methods, photovoltaic is now an established technology that is intrinsically safe. Over the course of a photovoltaic module's expected lifespan, it will generate much more energy than was used during its creation. Over two tons of carbon dioxide might be saved with only one hundred watts of power from a 100-watt module. While functioning, photovoltaic systems do not generate any noise or environmental damage. The environmental dangers of PV cell technologies are fewer than those of other forms of energy sources. But PV cell factories, installation sites, and recycling or disposal facilities all pose risks of releasing hazardous chemicals into the environment. Many different chemicals and materials are used in the manufacturing of photovoltaic devices. These include 1, 1, 1-trichloroethane, ammonia, acetone, methanol and isopropyl alcohol. Concerns regarding land degradation and habitat loss may be raised by the siting of bigger utility-scale solar installations; however, these effects may be mitigated by placing the plants in low-quality environments, such as existing traffic, transmission corridors, and former mining.

In **Table 1.** Below Presents Details of Optimum Exploitations, Advantages, and Disadvantages of Solar Energy.

**Table 1. Approaches for optimum Exploitations, Advantages, and Disadvantages of Solar Energy**

| | |
|---|---|
| **Approaches for Optimum Exploitations of Solar Energy** | Establishing and keeping up a critical data system on the different solar energy sources, and initiatives that are available. |
| | Giving energy commissions the resources they need to domesticate renewable energy technology, such as solar. |
| | Giving local solar energy system producers enough incentive |
| **Advantages of Solar Energy** | Sunlight energy comes at no cost. |
| | The sun is ecologically benign since it doesn't create greenhouse gases. |
| | Throughout our lifetime, the sun will always exist. It never runs out. |
| | By making use of the building's inherent heating and cooling systems, it reduces the needless and wasteful use of commercial energy. In locations without an electric network, it satisfies the requirement for energy. |
| **Disadvantages of Solar Energy** | Building solar power plants is quite costly. |
| | PV cells function at low power levels. |
| | The impact of planar collector methods may result in hazardous conditions for human health due to toxic heat transformations fluid and high temperatures. |
| | When there is the required light can electricity be generated. v. Workers who produce solar cells are exposed to toxic substances |

## III. WIND ENERGY

The depletion of fossil fuel reserves has made the exploration of renewable energy sources urgent. Demand for energy throughout the world is on the rise, too, threatening to trigger a worldwide blackout. Traditional energy sources are also a major contributor to atmospheric pollution and, ultimately, global warming. However, renewable energy sources like wind provide a practical and environmentally friendly alternative to fossil fuels. Wind is a viable renewable energy option because of its wide availability and cheap operational costs. Wind energy is one of the most increasingly renewable sources of energy. Lowered costs are contributing to a rise in consumption throughout the world. New data from IRENA shows that the world's installed capacity for onshore and offshore wind power production has expanded from 7.5 GW in 1997 to approximately 560 GW in 2018. From 2009 to 2013, the output of wind energy is more than quadrupled, and in 2016, wind energy accounted for approximately 16% of the overall renewable energy generation [9]. While there are many of places with sufficient wind speeds, the ideal sites for doing so are frequently far from civilization. The potential of wind energy generated far from land is vast.

Commercial wind turbine converts the kinetic energy of the wind into electricity by employing the rotational energy created by the turbine to power a generator, making wind power a kind of energy conversion. Wind turbines have a rotor or blade at their base and a nacelle at the top of a tall tower that contains the gearbox and other moving parts. The largest turbines, with rotor diameters of over 162 meters (531 feet) and tower heights of up to 240 meters (752 feet), can produce energy at 4.8 to 9.5 megawatts (787 feet). Whenever it comes to renewable sources of energy, wind is by far the most well-established and advanced. To generate electricity, it harnesses the kinetic energy produced when air flows across a turbine. It's good for the environment since it's a renewable energy source that doesn't release harmful gases. Sailboats and windmills have been in use since prehistoric times, respectively because of their reliance on wind power to propel them and turn their blades. Starting in the early 20$^{th}$ century, wind turbines have been employed to provide electrical power. The mechanical system works like this: the wind drives a propeller, which in turn turns the rotor of a generator, which in turn creates electricity. In order to improve energy efficiency and minimize environmental damage, wind turbines are often grouped together in wind farms. The machines are guaranteed to last for twenty years.

Using wind turbines, devices that transforms wind energy into electricity, generates wind energy, also known as wind power. The blades of turbines are linked to rotor, which in turn operates a generator, with the help of the wind. A distinction is made between the Vertical Axis Wind Turbines (VAWTs) [10] and Horizontal Axis Wind Turbines (HAWTs) [11] when it comes to the orientation of the blades. The HAWT wind turbine is now the most often used design. Like a plane's propeller, they typically have two or three long, thin blades. The rotor blades are pointed directly towards the wind. Blades on VAWTs are shorter and wider than those on conventional wind turbines, recalling the beaters on an electric mixer. Powering a home with 100 kilowatts is possible with only one wind turbine. Places like water pumping stations use small wind turbines as well. Larger wind turbines have towers as high as 260 feet (80 meters), and their rotor blades may be as long as 40 meters (130 feet). Massive wind turbines with rotor blades longer than 531 feet (162 meters) may be seen atop towers stretching 240 meters (787 feet) into the air.

Winds are caused by the earth's rotation and the fact that it is warmer near the equator than the poles. Wind turbines are able to harvest this oblique kind of solar energy and transform it into power. Between 1995 and 2004, global usage of wind power increased by a factor of almost seven, making it the fastest-growing energy source since 1990. When it comes to harnessing wind power, Europe is out in front. Even now, most of the world's potentials for wind energy is unused. Successful strategies to support renewable energy are shown by the current wind energy industry's rapid expansion. Capacity for wind power throughout the world has increased from a few hundred MW in 1990 to 2004 with approximately 48K MW. Since 2000, we've averaged 28% yearly growth.

### *Economic Advantages for Sustainable Development*

Wind power is becoming a viable and inexpensive renewable energy option. Even though the typical size of a turbine is just 2 MW, continued research has amounted to steadily massive turbines. Wind energy, despite improvements in turbine technology and wind energy, continues to account for just a small percentage of worldwide energy production. Wind energy plays an important part in power production, despite the fact that its possibility as a fundamental source of renewable sources of energy is constrained through high costs of maintenance and installing wind turbines and its relatively low output. In certain places, wind power alone accounts for a very high percentage of total energy generation. This is the case in Iowa (14%), Denmark (49%) and Schleswig-Holstein (40%). Wind power is a renewable energy source that, under the right circumstances, may supplement conventional power plants.

### *Wind Power: Worldwide Status Report*

It is predicted that by 2017, the capacity of installation of the world's windmills would provide enough electricity to meet around 10% of global demand. In 2016, the world's overall capacity of the wind energy has enhanced by approximately 12%, reaching about 487 GW. Although 2015's total additions were approximately 14% lower than the past record high, they still ranked as the year's second biggest market overall, behind only 2017. More than 90 countries had commercialized wind-producing activities by the end of 2016, and 29 countries across all regions had more than 1 GW running at the same time. Around 51 GW of capacity was added globally in 2018, down around 4% from 2017. This included almost 4.5 GW of offshore and 47 GW of onshore. All of the downturn in the market was due to onshore installations. After peaking in 2015, during which China alone developed more than 30 GW in projections of regulatory transformations, yearly installations have declined for the last three years. Additions in 2018 enhanced the overall capacity by 9 percent to approximately 590 GW, as depicted in **Fig 2**, with approximately 568 GW operating onshore and the remainder operating offshore.

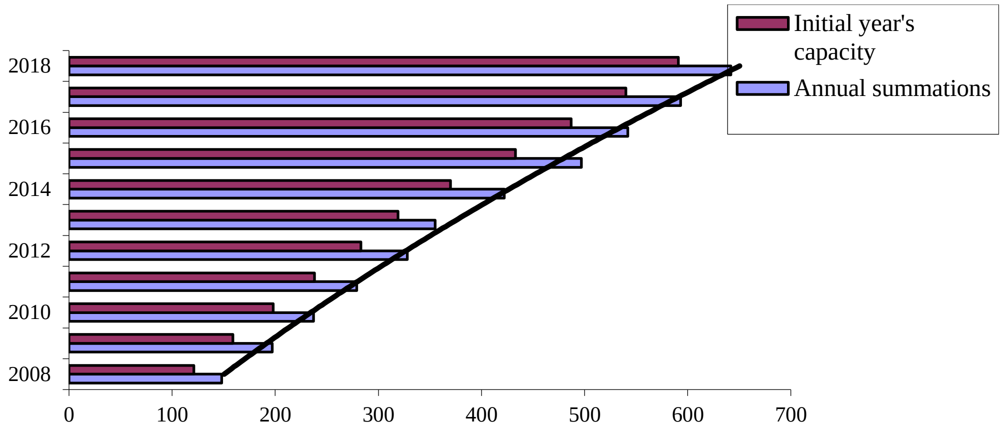


**Fig 2.** Wind Energy Annual Additions and Global Capacity From 2008 To 2018

*Environmental Impacts of Wind Energy*

When built on cultivated ground, wind farms have one of the fewest negative effects on the surrounding ecosystem. Besides being compatible with crops and grazing, this model generates the energy consumed in its constructions in approximately 3 months of operation, whereas its operational lifespan is about 20 to 25 years, making it the most land-efficient energy conversion system available. Construction-related emissions of greenhouse gases and air pollutants are negligible and falling. Nonetheless, wind power is annoying, may kill birds, and create parasites in radio and television equipment. The environmental impacts of wind turbines have led to bans on their construction inside or near national parks in several European nations, especially England. A 500-kilowatt wind turbine can remove as much carbon dioxide from the air as 57,000 trees. Wind power is good for the environment since it is a renewable source of electricity. **Table 2** presents a for optimum exploitations, advantages, and disadvantages of wind energy.

| **Table 2. Approaches for Optimum Exploitations, Advantages, and Disadvantages of Wind Energy** | |
|---|---|
| **Approaches for Optimum Exploitations of Wind Energy** | Training trained workers to provide the essential technical infrastructure needed for local manufacture of wind energy model components and parts. |
| | Establishing extension programmers to boost the implementation of wind energy technologies in general |
| | Giving users, developers and producers of wind energy systems the proper incentives. |
| | Educating knowledgeable local craftspeople to guarantee the functioning and upkeep of the wind energy model. |
| **Advantages of Wind Energy** | Wind energy is free and does not run out. |
| | Sources of energy are clean. The generation of wind energy does not produce GHG. |
| | Mechanical energy could be generated directly from wind energy. |
| | Wind turbines may be a fantastic source of energy in isolated regions (e.g. electricity). |
| | There are alternative uses for the land surrounding wind turbines, such as farming. |
| **Disadvantages of Wind Energy** | Only places with a lot of wind are suitable for using windmills. |
| | To produce more energy, more turbines are required. |
| | During periods of peak output, wind energy needs costly storage. |
| | The issue of noise pollution is often related to wind turbines. |
| | Requires wide open spaces for the installation of wind farms. |
| | Wildlife may be endangered. When birds fly into turbines, they do be hurt or killed. |
| | Because wind turbines include mechanical components that deteriorate over time, maintenance costs are considerable. |

## IV. BIOMASS ENERGY

Biofuels are gaseous or liquid forms of energy that may be produced by burning plant matter and animal wastes. Biomass refers to any organic substance that may be used as a fuel source, including plant matter (such as agricultural and wood waste) and animal manures. Since the beginning of human history, people have burned biomass for energy. However, by the midst of the 18$^{th}$ century, fossil fuels had supplanted biomass as the primary fuel source worldwide due to their greater abundance, higher energy density, and lower pollutant output during combustion [16]. Interest in biomass energy has increased in recent years because it is seen as a carbon-neutral source of fuel, in contrast to the overall carbon-producing fossil fuels, the excessive employment of which has contributed to climate change and global warming. Combustible organic chemicals created by photosynthesis make up biomass, which is an indirect product of solar energy [17].

*Economic Advantages for Sustainable Development*

The use of biomass (such as wood and dung) for heating and cooking typically accounts for approximately 11% of global energy consumption and 30% in developing nations. Around the world, about 70% of the population relies on wood or charcoal stoves for their primary source of indoor heating and food preparation [18]. But there isn't enough fuel wood to go around for the 2.7 billion people who live in these nations because they either can't find it or can't afford to purchase it. Some biomass may be converted into both liquid and gaseous bio fuels using bacteria and different chemical processes. Biogas (made up of 40% carbon dioxide and 60% methane) is one such example, as are ethanol and methanol in liquid form [19].

*Bio-Power: Global Status Report*

In 2016, bio-power capacity throughout the world grew by an estimated 6 percent, reaching 112 GW. The power output increased by 6% and reached 504 TWh. In 2016, the United States generated the most biomass-based power (68 TWh), followed by 54 TWh in China, 52 TWh in Germany, 51 TWh in Brazil, 38 TWh in Japan, 30 TWh in India, and 30 TWh in United Kingdom. According to **Fig 3**, the projected international bio-energy capacity increased by approximately 6% in 2018 increasing to about 130 GW from 120 GW in 2017. The overall bio-electricity amount produced increased by 9% in 2018, from 2017, which was 532 TWh to 581 TWh. With a 6% increase in production in 2018, the European Union (EU) maintained its position as the world's leading generator by area thanks to the stimulus provided by the Renewable Energy Directive. China and the rest of Asia had the highest growth in generation in 2018, both at 14%, while North America saw practically flat growth.

*Environmental Impacts of Biomass*

The combustion of biomass releases carbon and nitrogen into the atmosphere, which may lead to increased air pollution and pollutants. These emissions may even exceed those produced by more conventional fuels like coal or natural gas. Compared to open burning, e.g., in direct heating applications or wildfires, using wood biomass as a fuel may emit less particulate and other pollutants. According to a study by Vershinina, Dorokhov, Romanov, and Strizhak [12], biomass is the second greatest contribution to global warming. Since the cost of transportation is a major factor in the profitability of biomass power plants, the size of these facilities is determined by the accessibility of biomass in the immediate area. As a result, a worldwide biomass market has developed, making it possible to construct 1 MW production facilities at a reasonable cost thanks to advances in railway technology and the ability to carry goods through waterways. When biomass is burned, carbon is released into the atmosphere as carbon dioxide. Approximately 50% of the wood's mass is composed of carbon when it is dry. **Table 3** presents an overview of optimum exploitations, advantages, and disadvantages of Biomass energy.

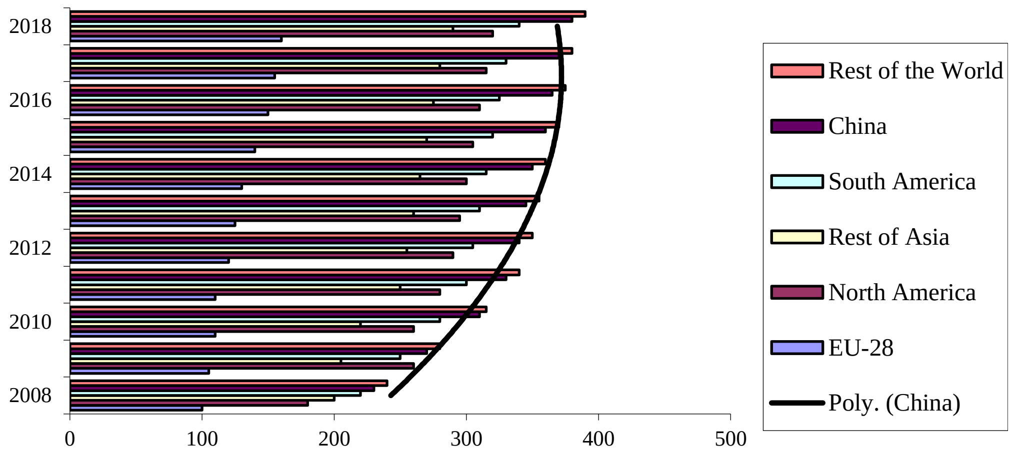


**Fig 3.** International Bio-Electricity Production Based on Region From 2008 To 2018

| Table 3. Approaches for Optimum Exploitations, Advantages, and Disadvantages of Biomass Energy | |
|---|---|
| **Approaches for Optimum Exploitations of Biomass Energy** | Promoting reforestation is a good idea. |
| | Increasing domestic capability for biomass production and use to lessen any negative health effects. |
| **Advantages of Biomass Energy** | It comes from a renewable energy source. |
| | Relatively speaking, it produces less pollutant. |

| | |
|---|---|
| | For agriculture and gardening, it supplies manure. |
| | Energy production from biogas has a huge potential. |
| | Reliably affordable and clean energy comes from biomass. |
| | Increasing biomass crops tends to absorb carbon dioxide and products oxygen. |
| **Disadvantages of Biomass Energy** | To produce biomass energy, a steady supply of biomass is necessary. |
| | It is challenging to transport biogas via a pipe over large distances. |
| | The production of ethanol uses a variety of readily cultivated cereals, such as maize and wheat. If an excessive amount of food crop is directed for usage as fuel, this might have negative effects. |
| | The crops that are utilized to provide biogas energy are periodic and do not grow all year round. |
| | Because biogas plants are expensive to build, only wealthy people can utilize them. |

## V. HYDROPOWER

Hydropower, typically referred to as hydroelectric power, is considered as a renewable source of energy that is produced by redirecting water flow through dams or similar structures. To generate electricity, hydropower plants make use of water, a resource that is never consumed nor wasted, thanks to the water cycle's never-ending recharge cycle. Hydroelectric stations come in a wide variety, but they are typically stimulated by the momentum of water that is in motion. Employing generators and turbines, hydropower transfers kinetic energy of water in motion into electricity, which could be employed to power factories, companies, and homes. Stations employing hydropower are often situated on or near a water source, since water is the primary resource for turning turbines and generating energy. The potential energy of a flowing water body is proportional to the product of the gradient (head) between its source and its destination, as well as the volume of the water flow. The amount of power produced depends on both the flow rate and the head height.

Water runs through a pipe (sometimes called a penstock) to drive a turbine, which in turn turns a generator to provide energy at the power plant level. This is how run-of-the-river systems and pumped storage hydroelectric plants typically function. Streams and rivers are formed when rain or melting snow flow down from higher elevations and make their way to the sea. Since the dawn of human history, this source of power has been heavily used. Dams may capture the water in rivers and streams, store it, and then release it to turn turbines and generate energy. Using the water cycle, the sun evaporates water, which then falls as rain or snow elsewhere. Dams and reservoirs may be used to harness the power of water moving from high to low altitudes in streams and rivers. Since the station's output can be rapidly ramped up or down in response to fluctuations in demand, it is also a very adaptable source of power.

*Economic Advantages for Sustainable Development*

The generation of electrical power by harnessing the weight of flowing or streaming water is known as hydropower, and the resulting hydroelectricity is known as hydroelectricity. It is anticipated to rise by roughly 3.1% annually for the next twenty-five years, making it the most commonly utilized source of renewable energy and responsible for 16% of worldwide power output (3,427 terawatthours of power generation in 2010) [13]. There are 150 nations that generate hydropower, with 32% of the world's hydropower coming from Asia and the Pacific in 2010. In 2010, China produced 721 TWh of hydroelectricity, enough to provide around 17% of the country's total electrical needs. The Xiluodu Dam and Itaipu Dam on the Paraguay and Brazil border, the Guri Dam in Venezuela and Three Gorges Dam in China are the four greatest hydroelectricity stations in the world. Because of its cheap price, hydroelectricity can compete with other renewable energy sources.

*Hydropower: Worldwide Status Report*

China has been responsible for more than a third of the world's newly installed hydroelectric capacity. Brazil, Ethiopia, Ecuador, Vietnam, Turkey, Peru, Lao People's Democratic Republic, India and Malaysia added the second-most capacity in 2016, after China. In addition, China installed more pumped storage capacity than any other country in 2015, followed by Switzerland, South Africa, Russia and Portugal. **Fig 4** presents a representation of worldwide hydropower consumption. The projected global generation from hydropower in 2018 was 4,210 TWh; however, this number is subject to change year-to-year based on weather and other regional factors. Separately measured pumped storage capacity throughout the world grew by around 1% last year. Approximately 35% of the globe's novel hydropower capacity was integrated in 2018, with China again in the forefront. As in 2017, Brazil came in second, followed by Pakistan and Turkey, each of which added more over 1 GW. Countries like Tajikistan, Angola, Ecuador, Norway, Canada and India all increased their production capacity significantly.

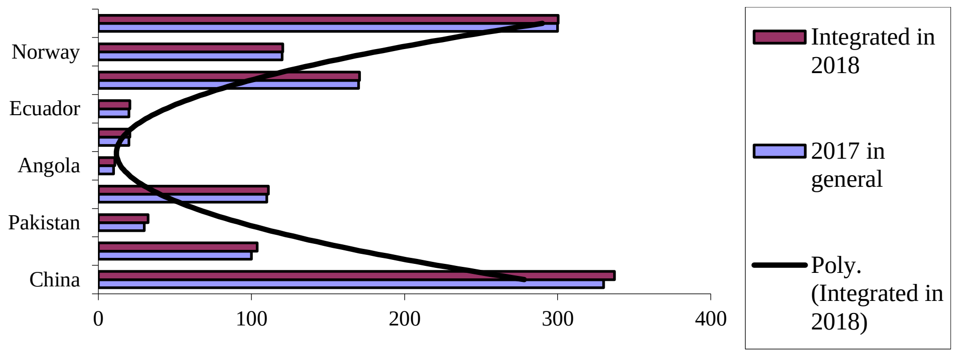


**Fig 4.** Worldwide Hydropower Consumption

*Environmental Impacts of Hydropower*

Climate, hydropower, ecology, society, economy, and culture are all impacted by hydroelectric power plants. When a hydroelectric power plant's reservoir is gathering water, it has an impact on the natural world. When compared to a river, a reservoir's surface area is much larger; hence its capacity to evaporate water has a greater impact on local weather patterns. As a result, the air becomes more humid, the speed at which air is moving changes and the frequency with which it rains and blows varies. Changing physicochemical properties and the stream's flow regime have hydrological consequences. The process of transforming rivers into reservoirs increases evaporation and the salt concentration, and other water minerals. As a stream slows down and eventually turns into a lake, its natural cleaning ability declines as a result of the decreased water speed, oxygen-taking and diffusion capacity of the lake.

Ecological implications include the blocking of land and sea migratory routes, the continued submergence of inhabited regions, and the extinction of key species. As a consequence of the expropriation, both external and internal movement events take place, and the land shift value, based on the value and size of the part under water. However, in integrated projects, the influx of workers during construction has a favorable impact on the local economy and the provision of infrastructural services and social services. The barrage lake may be used for both leisure and industrial purposes. However, if the area's historical landmarks and natural resources are not safeguarded, cultural qualities might be lost. **Table 4** discusses the optimum exploitations, advantages, and disadvantages of Hydropower energy

**Table 4. Approaches for Optimum Exploitations, Advantages, and Disadvantages of Hydropower Energy**

| | |
|---|---|
| **Approaches for Optimum Exploitations of Hydropower Energy** | Making sure there is more indigenous involvement in hydropower station planning, development, and construction. |
| | Providing the fundamental engineering framework for the manufacture of hydropower plants, machinery, and related products. |
| | Supporting the building and management of hydropower plants by the private industry, both domestic and international. |
| **Advantages of Hydropower Energy** | After the dam is constructed, power could be produced progressively. |
| | The sluice gates could be closed to cease energy production if it is not required. |
| | Recreational and fun activities could be undertaken in the lake, which creates behind the dam. Large dams often develop as standalone tourism destinations. |
| | Dam systems that generate energy do not emit greenhouse gases while they are in operation. |
| | Hydropower is a renewable source of energy. It cannot be used up, therefore. |
| | Adjustable: As was already indicated, changing the water flow and electrical production is simple. Water flow is decreased during periods of low power consumption, and magazine levels are saved for periods of high-power demand. |
| | Hydroelectricity is significantly safer. No fuel is used in this process. |
| **Disadvantages of Hydropower Energy** | Building a dam is quite costly. |
| | Through floods, it obliterates the natural habitat. |
| | Many issues with water availability are brought on by the construction of dams for hydroelectric electricity. |
| | Because a dam is being built, the land adjacent must be inundated, which may have an impact on the local fauna and vegetation. |

## VI. GEOTHERMAL ENERGY

Geothermal energy alludes to the heat, which is produced within the Earth's crust due to the planet's establishment and the radioactive decay. Some of the rocks melting and the solid mantle behave in a plastic way as a result of the increased pressure and temperature deep within the Earth. Since the mantle is less dense than the rocks around it, some of it will convect upwards. The core-mantle border is a region where temperatures may soar to nearly 4000 C (7200 F). Geothermal heating, for example utilizing water from the hot springs, has been employed for hydrotherapy dating from the Paleolithic era and for home heating since the Roman era. The generation of electricity from the geothermal power, or geothermal energy, has become more significant over the past few decades. Even though just a smaller proportion of the globe's geothermal resources are being employed efficiently at the current time, typically in the parts closers to the tectonic plate boundaries, it is considered that the resources are more than enough to meet energy demands of humans in the long run.

The production costs for geothermal energy dropped by a quarter between the 1980s and the 1990s due to government-funded research and business expertise. Newer innovations in technology have drastically decreased prices, increasing the scope and variety of potentially useful resources. The U.S. Department of Energy projects that the price of geothermal energy generated by a power plant "constructed today" will be roughly $0.05/kWh in 2021. In 2019, geothermal power capacity globally was estimated at 13,900 MW. As of 2010, an additional 28 GW of direct geothermal energy capacity has been added for use in district heating, heating systems, spas, industrial operations, desalination, and agricultural uses. Assumptions concerning the state of technology, energy pricing, subsidies, plate boundary movement, and interest rates all play a role in future geothermal power prediction. EWEB's consumer opt in Green Power Initiative is an example of a pilot program that demonstrates the public's interest in paying a premium for renewable energy sources like geothermal.

Geothermal energy is considered the heat potentials stored in the earth's crust at depths that can be reached economically. A sustainable source of energy, this one is safe to use. Technologies that convert one kind of energy into another allow for the generation of electricity as well as the direct utilization of thermal energy from sources like steam and boiling water. Due of its harmful impact on the environment, the waste fluids from which energy is produced is injected deep down. The core of the Earth is thought to be the source of geothermal energy in the form of heat from nuclear processes. It is thought that the temperature in the center of the Earth is over 5,000 K, and that temperatures may rise to 90°C only 4 km below the surface due to the conductive properties of the rocks there. Local geothermal energy potential is substantially higher in regions with geothermal energy, geysers, hot rocks, or volcanoes. Total geothermal energy production is predicted to be about 1016 PJ (whereby1 PJ equals 1015 J). More than twice as much energy is being released to the earth's surface from the core as is being used by humans every year—roughly 44 TW (1 TW = 1012 W). This heat, however, is too dispersed (0.1 W/m2) to be retrieved without a more concentrated geothermal resource at a specific place. Assuming a constant rate of use of 44 TW, then geothermal resource for heat will be finished in about 1012 years.

*Economic Advantages for Sustainable Development*

In order to produce power, this renewable resource is put to good use. Geothermal plants in the Philippines provide 27% of the country's electricity, those in California State provide 7%, and those in Papua New Guinea generate 56MW of electricity from the earth's heat and pressure. Gold mining relies on geothermal energy for 75 percent of its energy needs. According to a 2006 study by Senpnar and Gencoolu, 86% of Iceland's total heat energy (city heating) comes from geothermal. Subsection

*Geothermal Power*

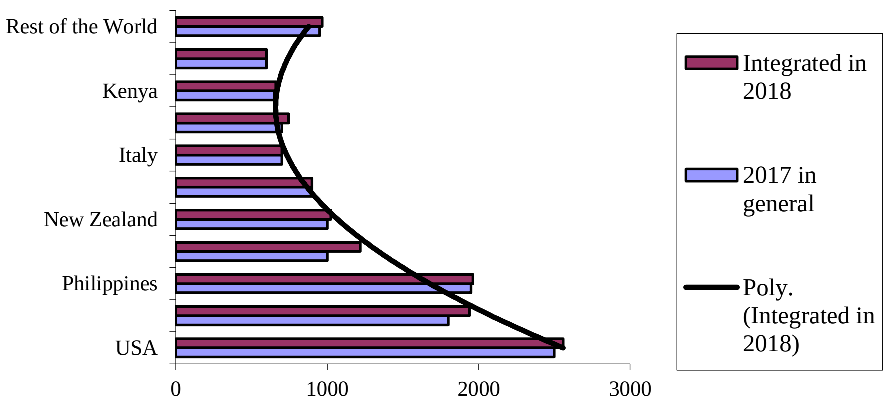


**Fig 5.** Geothermal Power Additions And Capacity In Top Countries

Worldwide Update at the end of 2016, the nations with the most geothermal power producing capacity were the Japan (0.6 GW), Kenya (0.6 GW), Iceland (0.7 GW), Turkey (0.8 GW), Italy (0.8 GW), Mexico (0.9 GW), New Zealand (1.0 GW), Indonesia (1.6 GW), Philippines (1.9 GW), and United States (3.6 GW). In 2016, Indonesia incorporated about 200 MW of novel capacity, summing the total to 1.64 GW at year's end. Also, one of the world's biggest geothermal facilities, the 110 MW Sarulla plant, began commercial operations in the nation in early 2017. In order to maximize energy extraction and efficiency, the plant uses a combined-cycle design, much like a Turkish facility that will go live in 2017. This design consists of traditional flash turbines and a binary model for emitting more energy from the steam produced by the flash turbines. The

Japan, Kenya, Iceland, Italy, Mexico, New Zealand, Turkey, the Philippines, Indonesia, and United States ranked first through fifth, respectively, in terms of geothermal energy production capability as of the end of the year see **Fig 5**.

*Environmental Impacts of Geothermal Energy*

Geothermal energy is regarded as the most environmentally friendly form of power since so many nations that utilize it also practice reinjection. Geothermal energy's near-zero wastefulness when converted into electricity outperforms that of fossil fuels when only sulfide emissions are taken into account for comparison. The emissions of nitrous oxide from geothermal power stations are fundamentally lower compared to those from fossil fuel energy plants. Since geothermal power plants pose no known threats to the ozone layer or human health, they are included among the cleanest energy options available.

*Advantages and Disadvantages of Geothermal Energy*

Palomo-Torrejón, Colmenar-Santos, Rosales-Asensio, and Mur-Pérez [14] list many benefits of geothermal energy, including the following: i) It is ecologically beneficial; it creates no greenhouse gases. ii) Water is heated and evaporated using natural resources. iii) There is an infinite supply of the energy that is used. Aytekin, Erhan, Erişgin, Esenyel, and Takır [15] list the need for re-injection due to the production of gases like hydrogen sulfide and carbon dioxide as one of the drawbacks of geothermal energy. On rare occasions, poisonous gases and minerals might rise from the earth's surface. Tackling one of them may be challenging.

## VII. CONCLUSION

This paper has presented a discussion of solar energy, wind energy, biomass energy, and hydropower. The benefits to the economy, environmental effects (including on global warming), pros and cons, and methods for optimal utilization are also discussed in this study with regards to renewable energy sources and their role in sustainable development. When properly used, nature's bounty may help humans achieve a high quality of life via industrialization without causing irreparable harm to the planet. The vast majority of renewable energy sources are both safe for ecosystems and highly efficient power plants. While it's true that installing certain renewable energy facilities may be costly, doing so could be a vital step towards minimizing greenhouse gas emissions and safeguarding global resources. Governments and businesses should give renewable energy sources including wind, solar, geothermal, biomass, and hydropower substantial consideration and support. In order to protect the planet's natural resources and prevent future generations' progress from being stunted, sustainable energy systems are essential.

### Data Availability

No data was used to support this study.

### Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.


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### Ethics Approval and Consent to Participate

The research has consent for Ethical Approval and Consent to participate.

### Competing Interests

There are no competing interests.

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